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THE PHILIPPINE JOURNAL OF SCIENCE

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JOSE KABIGTING SANTOS

Of the one-hundred fourteen charter members originally appointed by the Governor-General of the Philippines in 1934 following the enactment by the Philippine Legislature of Act No. 4120 creating the National Research Council of the Philippines, only eighty-one remained at the time of the death on August 6, 1949 of the late José Kabigtíng Santos, former Professor and Head of the Department of Botany of the University of the Philippines. This irreparable loss of one of the outstanding Filipino scientists was keenly felt by his many friends and associates. The National Research Council of the Philippines, the consulting and advisory body to the Republic on matters pertaining to science and scientific research, has been directly affected by the death of Doctor Santos, not only because of the passing of the charter member who was responsible for the idea of holding the first Philippine Science Convention in 1932 during his incumbency as President of the Philippine Scientific Society, but also because of the marked decrease in the ranks of its members devoted to botanical research. Thus Dr. Bienvenido M. Gonzalez, President of the University of the Philippines, Charter Member and for more than ten years, Chairman of the National Research Council of the Philippines, fittingly eulogized the late José Kabigtíng Santos both in the obituary prepared by the Executive Board of the National Research Council of the Philippines and in the announcement of the passing of José Kabigtíng Santos transmitted to every member and associate of the National Research Council on August 11, 1949.

José Kabigtíng Santos was born in Arayat, Pampanga, on February 4, 1889. The son of Lucio de los Santos and Natalia Kabigtíng, he was at the time of his death a little over 60 years

of age. His early education was obtained in the *Liceo de Manila,* one of the first private schools founded and supported by Filipino educators from whom a number of undergraduate and advanced students were selected to become members of the first group of Filipino pensionados who were sent by the Philippine Government to various colleges and universities of the United States to pursue advanced professional, scientific and technical studies. At the beginning of the academic year 1911–1912, José Kabigtíng Santos enrolled in the Course in Pharmacy offered in the College of Liberal Arts, which was to become the College of Pharmacy of the University of the Philippines with the late Dean Andrew Grover DuMez of the College of Pharmacy of the University of Maryland as its first director. Even during his residence as a student in the University of the Philippines, he displayed a keen interest in botany and an exceptional ability in scientific illustrations especially in the different courses he took in the Department of Botany of the University. He also showed enthusiasm in other activities that the state's highest institution of learning was promoting among her students. For his ability and leadership, the student body of the School elected him President of the University of the Philippines Pharmaceutical Association. This organization included among its members every student enrolled in the School of Pharmacy and was undertaking activities designed to promote the welfare of pharmacy students and the success of the School of Pharmacy in its avowed mission.

Serving as Student Assistant in the Department of Botany of the University of the Philippines, he graduated in 1916 with the degree of Graduate in Pharmacy. Immediately after his graduation, he was appointed Assistant Instructor in Botany in the College of Liberal Arts. In 1918, he was promoted to the position of Instructor in Botany. During the early years of his connection with the Department of Botany of the College of Liberal Arts, he had the opportunity of associating himself with well-known botanists who had spent the greater part of their lives undertaking botanical research in the Philippines, such as Dr. Elmer D. Merrill, former professor of botany in the University of the Philippines and Director of the former Bureau of Science, now with Harvard University; and the late Dr. William H. Brown, former professor of botany in the University of the Philippines and Director of the former Bureau of Science.

Realizing his bright prospects, the University authorities appointed him Fellow of the University of the Philippines

abroad. He left Manila in August, 1919, together with other pensionados of the Philippine Government. Upon his arrival in the United States, he enrolled in the University of Chicago. Notwithstanding his handicaps for not having completed a bachelor's degree, he was allowed to enroll in the University of Chicago in courses that would prepare him for graduate work. The excellent work he performed enabled him to obtain in 1921 the degree of Bachelor of Science *with honors* from the University of Chicago. He then enrolled in the Graduate School of the same university, majoring in botany. At the end of the academic year of 1922, the same university conferred upon him the degree of Master of Science. He continued his graduate work leading to the doctorate degree. At the commencement exercises of the University of Chicago in 1923, he was conferred the coveted degree of Doctor of Philosophy *magna cum laude*. His main research work, the results of which he used for his doctoral dissertation, dealt mainly with his studies on the differentiation of chromosomes and determination of sex in *Elodea*. These two papers were published in the *Botanical Gazette*.

While in the United States, José Kabigting Santos and Dr. Joaquin M. Marañon were appointed official delegates of the College of Pharmacy of the University of the Philippines to the 1921 Annual Meeting of the American Association of Colleges of Pharmacy, formerly American Conference of Pharmaceutical Faculties held in Cleveland, Ohio. They also represented the Philippines in the 1921 Annual Meeting and National Convention of the American Pharmaceutical Association held also in Cleveland, Ohio. On his way home in 1923, he had occasion to visit leading botanical laboratories in renowned universities in London, Vienna, Paris, Belgium, and Switzerland.

Upon his return to the University of the Philippines, he was appointed Assistant Professor of Botany in 1924 in the College of Liberal Arts. He devoted his time to teaching different botanical courses in the University of the Philippines. There was not a single year when he did not conduct and supervise the botanical excursions that the Department of Botany organized regularly for the purpose of instilling in the minds of students of botany the importance of systematic botany and the indispensable corollary of this work, mainly the actual work in the field that enable systematic botanists to learn plant characteristics. He also began studies in the pharmacognosy of Philippine medicinal plants as early as the first year after

his arrival in the Philippines from his trip abroad. His first contribution to the pharmacognosy of Philippine plants was a paper on *Chenopodium ambrosioides* L. published in the *Philippine Journal of Science* in 1925. In 1925 he was appointed Acting Head of the Department of Botany of the University of the Philippines. In 1926 he was promoted to Associate Professor of Botany.

During all the years of his teaching of both undergraduate and graduate courses in botany, he was actively engaged in undertaking research on cytology and the pharmacognosy of Philippine medicinal plants. It was especially his appointment as part-time Botanist of the former Bureau of Science in 1924 (a position which he held continuously for ten years until 1934) that enabled him to devote a great deal of his time to botanical research. He was also invited to contribute a paper on cytology in a special jubilee number of *Cytologia* issued by the International Cytological Association with headquarters in Japan. Not only was he an active research worker but he also spared no efforts in attracting many of his young associates to study advanced courses in botany and to undertake original botanical investigations. He did this work so well that he was instrumental in sending many young members of the faculty to pursue advanced studies in the United States. Several of those students have returned to the Philippines to serve their country and people after obtaining their advanced training in various phases of botanical work.

In 1934, he became permanent Head of the Department of Botany of the College of Liberal Arts of the University of the Philippines. When an exchange of professors between the University of Michigan in Ann Arbor and the University of the Philippines was established in 1934, Professor H. H. Bartlett, Chairman of the Department of Botany of the University of Michigan, came to the University of the Philippines as Exchange Professor. At the same time the late José Kabigtíng Santos was appointed Exchange Professor of Botany in the University of Michigan. There he spent the academic year 1934–1935 teaching botany. During this second trip abroad, he attended the Sixth International Botanical Congress held in Amsterdam, Holland, as an official delegate of the University of the Philippines. On his way home from Europe, he and his family visited London, Berlin, Brussels, Belgium, and France. They also spent three months in Spain, partly because they were stranded in

Europe as a result of the Italo-Ethiopian War. From Spain they went to Italy and then to Marseilles, France, where they finally took passage for Manila.

As president of the Philippine Scientific Society, then a very active instrument for the dissemination of scientific knowledge, he was mainly responsible for the idea of holding the First Philippine Science Convention in 1932. Under his leadership, this national science convention took shape.

Scientists from different branches of the Government, the University of the Philippines, and other universities, colleges and professional organizations cooperated wholeheartedly to make that memorable convention a huge success. It was during that convention when at the behest of Filipino scientists, the late President Manuel L. Quezon publicly announced his support for the establishment of a National Research Council of the Philippines. Thus José Kabigting Santos contributed his share in more ways than one to the progress of science in our country.

The full appreciation of the value of research by José Kabigting Santos is well illustrated by the following excerpts from his presidential address entitled "Science and the Country" delivered during the Opening Session of the First Philippine Science Convention: *

> As I have stated before, scientific mindedness is necessary for the advancement and prosperity of this country; but scientific mindedness alone without its necessary tool—research—is meaningless—an empty phrase! And I need not tell you that for the development of our natural resources, research in pure and applied sciences is indispensable; nor do I need to tell you that our country is economically poorer, though potentially richer, than many countries of its size in the world because we are behind in scientific research. It is high time, therefore, that we give our most serious attention to this vital question. We must solve it now; further delay may prove disastrous to our economic future and fatal to our political aspirations. Our government must establish more experimental stations, and improve upon and enlarge its existing laboratories, or authorize the establishment of new ones. Our colleges and universities must within the limit of their ability and resources, do their full share in furthering scientific research. In fact, they should be made responsible for the scientific progress of the country inasmuch as they are responsible for the scientific education of our youth.

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* Proceedings of the First Philippine Science Convention held under the auspices of the Philippine Scientific Society, March 15, 16, 17 inclusive, 1932, Manila. *University of the Philippines Natural and Applied Science Bulletin*, v. 2:165–308.

We, who have had the fortune of being trained in the ways of science, who live in intimate contact with it, who labor under its lure and influence, have a duty to perform and a responsibility to discharge towards our country and people. We do not, we cannot, dodge this duty and this responsibility; but to faithfully fulfill them we need help and encouragement. We have faith in our ability to build the scientific structure of our country provided adequate means are given to us. As the framework of this structure it would perhaps be necessary to organize an institution like the National Research Councils or the National Academy of Sciences of various progressive countries.

With the ever living, ever growing desire in our hearts to serve this Pearl of the Orient Seas—the one spot in the whole creation which God, in His infinite wisdom, has given us to dwell in happily, to own, to develop for our benefit and contentment, to love and to defend—let us exert our best effort to make her self-sufficient and promote her general welfare by leading her along upon the charted highway of science and by inculcating in her youth the love of research for the sake of truth and for the material blessings that research affords.

Speaking of Doctor Santos, the President of the University of the Philippines, Dr. Bienvenido M. Gonzalez, Chairman of the National Research Council of the Philippines, said:

As President of the Philippine Scientific Society, he was mainly responsible during his incumbency of introducing the idea of holding a Philippine Science Convention in 1932. It was such a success that when the National Research Council of the Philippines was created, the Philippine Science Convention was held regularly under the joint auspices of the National Research Council of the Philippines and the Philippine Scientific Society until the war broke out.

As an author, he published a manual entitled, *Experimental Botany* (Manila, Educational Supply, 1934, pages XIV, 235). This manual is at present used by the University of the Philippines in the classes of botany in Quezon City, Cebu and Iloilo and by other universities and colleges in the Philippines. He was contributing editor of *The Philippine Journal of Science* and the *University of the Philippines Natural and Applied Science Bulletin.*

He held membership in professional and learned societies, namely, the Philippine Pharmaceutical Association, the Philippine Scientific Society, the *Colegio Médico-Farmacéutico de Filipinas,* the American Association for the Advancement of Science, of which he was a Fellow, the Sigma Xi and the Society for Advancement of Research. In the National Research Council of the Philippines he held membership in the Sections of Pharmacology, Organic and Plant Chemistry, Pharmacopoeia, Genetics, Botany, and Chemical and Biological Defense. He is listed in the American Men of Science, 4th edition, 1927, New

York, the Science Press, p. 854, in the World Biography, 1948, published by the Institute for Research in Biography, 296 Broadway, New York 7, New York; and also in Bulletin No. 7 issued in February, 1934, of the National Research Council of the Philippines, wherein biographical data and a bibliography of his works are given (pages 734–736).

On September 30, 1925, he married Felisa de la Peña, a holder of the degree of Pharmaceutical Chemist from the College of Pharmacy of the University of the Philippines with whom he had three children.

His love of pharmacy manifested itself again when during the latter part of his life he and his wife engaged in the manufacture in their own laboratory of the well known Jofel's * preparations, namely Jofel's medicinal cigarette, Jofel's asthma relief powder and Jofel's asthma paper. These preparations were made chiefly from the flowering tops of *Datura alba* Nees, or *Datura fastuosa* Linnæus and from the entire herb of *Euphorbia hirta* Linnæus.

The appended bibliography represents the results of the painstaking research work that he pursued during his life.

PUBLICATIONS OF DR. JOSÉ KABIGTÍNG SANTOS

1. Differentiation among Chromosomes in *Elodea.* Botanical Gazette 75 (1923) 42–59.
2. Determination of Sex in *Elodea.* Botanical Gazette 77 (1924) 353–376.
3. A Pharmacognostical Study of *Chenopodium ambrosioides* Linnæus from the Philippines. Philip. Jour. Sci. 28 (1925) 529-547.
4. Histological Study of the Bark of *Alstonia scholaris* R. Brown from the Philippines. Philip. Jour. Sci. 31 (1926) 415-429.
5. Pharmacognostical Study of *Datura alba* Nees and *Datura fastuosa* Linnæus from the Philippines. Philip. Jour. Sci. 32 (1927) 267–296.
6. Stem and Leaf Structures of *Tinospora rumphii* Boerlage and *Tinospora reticulata* Miers. Philip. Jour. Sci. 35 (1928) 187–208.
7. A Cytological Study of *Cocos nucifera* Linnæus. Philip. Jour. Sci. 37 (1928) 417–437.
8. Histological and Microchemical Studies on the Bark and Leaf of *Artabotrys suaveolens* Blume from the Philippines. Philip. Jour. Sci. 38 (1929) 269–282.
9. Leaf and Bark Structure of Some Cinnamon Trees with Special Reference to the Philippine Species. Philip. Jour. Sci. 43 (1930) 305–365.
10. A Critical Morphological Study of *Thalassia hemprichii* (Ehrenb.) Aschers from the Philippines. Univ. Philippines Nat. and Appl. Sci. Bull. 1 (1930) 1–19.

* The word was coined from the first syllable of Jose and Felisa, his first name and that of his wife.

11. Pharmacognosy of Philippine Drugs. Jour. Philippine Pharm. Assoc. 2 (1930) 148–162.
12. Philippine Drugs. Jour. Philippine Pharm. Assoc. 2 (1930) 211–212c, 245–249a, 282–287; 3 (1931) 124–129, 189–194; 4 (1932) 316–327, 324–333.
13. Anomalous Stem Structure in *Archangelisia flava* and *Anamirta cocculus* from the Philippines. Philip. Jour. Sci. 44 (1931) 385–407.
14. Leaf and Seed Structure of a Philippine Coriaria. Philip. Jour. Sci. 46 (1931) 257–268.
15. A Contribution on the Life History of *Dendrobium anosmum* Lindley, by Maria D. Pastrana and José K. Santos. Univ. Philippines Nat. and Appl. Sci. Bull. 1 (1931) 133-144.
16. Anatomical Study on the Culm of Five Philippine Bamboos, by Gregorio T. Velasquez and José K. Santos. Univ. Philippines Nat. and Appl. Sci. Bull. 1 (1931) 281–318.
17. Scientific Contributions of the Department of Botany. Univ. Philippines Nat. and Appl. Sci. Bull. 1 (1931) 405–413.
18. The Laticiferous Vessels and Other Anatomical Structures of *Excoecaria agallocha*. Philip. Jour. Sci. 47 (1932) 295-304.
19. Morphological and Chemical Studies on the Seeds of *Erythrina variegata* var. *orientalis* (Linnæus) Merrill, by Joaquin Marañon and José K. Santos. Philip. Jour. Sci. 48 (1932) 563–580. Also in Univ. Philippines Nat. and Appl. Sci. Bull. 2 (1932) 215.
20. On the Microsporogenesis of *Saccharum spontaneum* Linnæus with Special Refenrence to Its Chromosome Number. Univ. Philippines Nat. and Appl. Sci. Bull. 2 (1932) 211.
21. *Science and the Country.*—Address by Dr. José K. Santos, President of the Philippine Scientific Society, during the First Philippine Science Convention held under the auspices of the Society, March 15–17, 1932, in the Univesity of the Philippines, Manila. Univ. Philippines Nat. and Appl. Sci. Bull. 2 (1932) 174–180.
22. Morphology of the Flower and Mature Grain of Philippine Rice. Philip. Jour. Sci. 52 (1933) 475–497.
23. Macrosporogenesis of *Lilium philippinense* Baker. Paper read at the Fourth Philippine Science Convention held under the auspices of the National Research Council of the Philippines and the Philippine Scientific Society, February 23–27, 1937, in the University of the Philippines, Manila. Abs. Nat. Research Council of the Philippines Bull. No. 19 1938) 105.
24. Anatomical and Microchemical Studies of *Strophanthus cumingii* A. DC. Paper read at the Fourth Philippine Science Convention held under the auspices of the National Research Council of the Philippines and the Philippine Scientific Society, February 23–27, 1937, in the University of the Philippines, Manila. Abs. Nat. Research Council of the Philippines Bull. No. 19 (1938) 137–138.
25. A Tentative Pharmacopoeial Monograph on Tiki-tiki or Rice Bran. *Revista Filipina Med. Farm.* 28 (1937) 337–342.
26. The Need for an Extensive Investigation of Philippine Medicinal Plants. *Revista Filipina Med. Farm.* 29 (1938) 165–168.
27. A Pharmacognostical Study of *Mallotus philippinensis* (Lam.) Müell.-Arg. *Revista Filipina Med. Farm.* 29 (1938) 405–416.

28. Pharmacognostical Study of *Strophantus cumingii* A. DC. from the Philippines. *Revista Filipina Med. Farm.* **30** (1939) 365–386.
29. The Origin and Development of the Female Gametophyte of *Hedychium coronarium* Koenig. Paper read at the Fifth Philippine Science Convention held under the auspices of the National Research Council of the Philippines and the Philippine Scientific Society, February 21–26, 1939, in the University of the Philippines, Manila. Abs. Nat. Research Council of the Philippines Bull. No. **32** (1939) 167–168.
30. Macrosporogenesis and Development of the Female Gametophyte of *Asparagus sprengeri.* Paper read at the Fifth Philippine Science Convention held under the auspices of the National Research Council of the Philippines and the Philippine Scientific Society, February 21–26, 1939, in the University of the Philippines, Manila. Abs. Nat. Research Council of the Philippines Bull. No. **23** (1939) 172–173.
31. Pharmacognostical Study of *Quisqualis indica, Lochnera rosea, Euphorbia hirta* and *Premna adorata. Revista Filipina Med. Farm.* **32** (1941) 197–212.

PATROCINIO VALENZUELA
Dean, College of Pharmacy
University of the Philippines

A REVISION OF THE GENUS ECTENUS DALLAS, WITH DESCRIPTION OF A NEW SPECIES (HEMIPTERA, PENTATOMIDÆ) [1]

By Leopoldo B. Uichanco
College of Agriculture, University of the Philippines

Ectenus Dallas is a small genus, which so far has been recorded almost exclusively from the Philippines, with the exception of a single species from New Guinea (Waigiu and Mysol). Hence, although the group is considered a Papuan derivative (Breddin, Abhandl. Naturf. Ges., Halle **24** [1901] 164), its headquarters apparently lie in the Philippines, wherein each species exhibits a strong local endemism. The known forms may be differentiated with the aid of the key included in the present paper, although in some cases separation is rather difficult, owing to the tendency of certain species to merge. The habits of none of the species are known. Unfortunately, because there was no material of *pudicus* and *brevirostris* on hand, sole reliance had to be made on published descriptions for their apparent diagnostic characters. All the specimens referred to herein, which formed part of the collections of the Bureau of Science and of the College of Agriculture, were destroyed by enemy action in February, 1945. It will probably take years to reconstitute the collection. However, it is deemed that the present diagnostic treatment will help in the recognition of the various forms, so that, although a restudy is indicated based on new material, release of this report obviously has its justification. Moreover, the specific collection localities given for each form serve to supply these distributional data for papers by Stål and other earlier authors, who merely reported "Philippines" or "Manila" for material studied by them from any of the islands of the Philippine group.

The species included in the present paper are:

1. *Ectenus generosus* Stål
   Sulu Archipelago
2. *E. mesoleucus* Bergroth
   Luzon and Polillo

[1] Experiment Station, College of Agriculture, Contribution No. 1543. Received for publication August 5, 1949.

3. *E. spinosus* sp. nov.
   Negros
4. *E. pudicus* Stål
   Mysol and Waigiu
5. *E. spectabilis* (Burmeister)
   Luzon
6. *E. æreus* Stål
   Biliran, Bohol, and Mindanao
7. *E. brevirostris* Stål
   Philippines; specific locality unknown

Genus ECTENUS Dallas (1851)

Genotype: *Cimex spectabilis* Burmeister (Philippines)

Close to *Dalpada* Amyot et Serville (tribe Halyiini), differing therefrom principally in that the first antennal segment in *Ectenus* is longer than the marginal space on the head between the eye and the insertion of the antenna, the first rostral segment extends markedly beyond the bucculæ, the part of the scutellum bounded by the frena is much longer than broad at the base, and the postfrenal part is narrower.

Key to the known species of Ectenus

1. Bucculæ not prominently produced anteroventrad, anteriorly describing a right or subacute angle. Postfrenal part of scutellum broader, more or less broadly rounded apically, almost entirely stramineous, sublævigate, sparsely punctured; basal angles each with a stramineous, sublævigate spot, which is as large as apical spot or smaller. Robust species; width of body about one-half length 2

   Bucculæ prominently produced anteroventrad into an acute or subacute process. Postfrenal part of scutellum narrower, roundly subacute at apex; stramineous, lævigate spot only thinly bordering apical and lateral areas; stramineous, lævigate spot at each basal angle diffuse or wanting. More slender species; width of body slightly or considerably less than one-half length 5

2. Head subequal in length to pronotum. First antennal segment not extending beyond apex of head. Lævigate spot on postfrenal projection of scutellum generally impunctate; lævigate spots at basal angles usually as large as apical spot. An obsolescent sulcus barely extending to caudal margin of third abdominal sternite. ..... *generous* Stål

   Head markedly shorter than pronotum. First antennal segment extending by about one-third its length beyond apex of head. Lævigate spot on postfrenal part of scutellum conspicuously punctured; lævigate spots at basal angles much smaller than apical. A well-defined median sulcus extending to apex of fourth or to about middle of fifth abdominal sternite 3

3. Lateral angles of terminal abdominal segments only moderately dentate, those of sixth armed with a short spine. External genitalia of female broadly rounded at apices. Lateral halves of propleura very deeply and thickly punctate ..... *mesoleucus* Bergroth

Lateral angles of terminal abdominal segments very prominently dentate and armed with rather long spines. External genitalia of female acute. Propleura very sparsely and shallowly punctate, except for a small irregular patch near lateral margin 4

4. Second antennal segment slightly shorter than basal ..... *pudicus* Stål

Second antennal segment about one-half longer than basal..... *spinosus* sp. nov.

5. Anterior angle of pronotum with a conspicuous ectally directed denticle; humeral angle more prominent, subacute; anterior area of pronotum broadly subconfluent with posterior. Second antennal segment somewhat longer than third 6

Anterior angle of pronotum without prominent denticle; humeral angle of pronotum less salient, somewhat rounded; anterior area of pronotum more strongly gibbous, between lateral one-fourth distinctly delimited from posterior by a transverse uniserially punctate impression. Second and third antennal segments usually subequal in length ..... *spectabilis* (Burmeister)

6. Rostrum extending to about middle of fifth abdominal sternite. Median sulcus extending to base of, or midway into, fifth abdominal sternite ..... *æreus* Stål

Rostrum extending to, or only a little beyond, caudal margin of third abdominal sternite. Median ventral sulcus on abdomen shorter or posteriorly more obsolescent ..... *brevirostris* Stål

ECTENUS GENEROSUS Stal

Stål. Ann. Soc. Ent. France, Ser. 4 (1865) 167;
Öfv. Vetensk.-Akad. Förhandlingar (1870) 622.

This species is apparently quite rare. There are available to me only three specimens. All of these were collected from the coral islands of the Sulu Archipelago, wherein the species is probably endemic.

Jolo Island, Bud Dajo (*A. Duyag*), 1 ♀, (*A. Lopez*), ♀; Banaran Island, Tawi-Tawi Group (*A. Duyag*), 1 ♂.

ECTENUS MESOLEUCUS Bergroth

Bergroth, Ann. Soc. Ent. Belgique 57 (1913) 150–151.

Closely resembling *E. generosus* in size, body conformation, and general color pattern, but the two species are readily separable with the aid of the key. In addition, the male anal segment is deeply sinuate in *generosus*, while in *mesoleucus* it is only broadly so.

POLILLO, October, 1909, B. S. Acc. No. 13031 (*McGregor*), 1 ♂, 1 ♀ (paratypes); LUZON, Mt. Maquiling, elevation 350 meters, September 23, 1932 (*P. Obien*), 1 ♀; elevation 900 meters, September 4, 1932 (*J. Alhama*), 1 ♀; Mt. Banahao, March 23, 1907 (*Banks*), 1 ♀; 1914 (*J. Valdez*), 2 ♀; Nueva Vizcaya (*Alzapan and Ramos*), 1 ♂.

Three males and 4 females (one female bearing identification label in Dean C. F. Baker's handwriting), collected from Los Baños, Laguna, by various collectors, May, September and October, 1914 to 1925. Up to about the latter year, "Los Baños" was used in a broad sense in the insect labels of the College of Agriculture collection, and was often made to include material from Mt. Maquiling at different elevations.

ECTENUS SPINOSUS sp. nov.

Length of body 17 millimeters, width between humeral angles 7. Ground color above dark green, with light brownish olivaceous. Other characters as given in key above.

Closest apparently to *Ectenus pudicus* Stål from Mysol and Waigiu, but differing from this principally by the second antennal segment being considerably longer than basal, in color characters and in the more densely and deeply punctate body above.

NEGROS ISLAND, Negros Oriental, near Lake Dako (collector?), in the Bureau of Science collection, 1 ♀ (type, burnt in 1945).

ECTENUS SPECTABILIS Burmeister

Burmeister, Nova Acta Acad. Leopold. 16, Suppl. 1 (1834) 291, Pl. 51, fig. 5 (*Cimex*); Dallas, List of the specimens of hemipterous insects 1 (1851) 174, Pl. 5, fig. 5; Stål, Ofversigt Vetensk.-Akad. Fördhandlingar (1870) 621.

Two specimens in the lot before me have antennal segment 2 somewhat longer than 3 and a third specimen has the humeral angles subacute, as in *æreus* Stål; but the sum of the other characteristics makes their identity as *spectabilis* beyond question.

LUZON, Laguna, Mt. Maquiling, mainly at and near summit, 1070 meters, occasionally at lower elevations, 13 ♂♂, 40 ♀♀ (various student collectors), mostly during rainy season, from June to October; Tayabas, Quezon National Park, near Atimonan, April, 1931 (*José Campo*), 3 ♂♂, 5 ♀♀; Mt. Bulusan, elev. 350-800 m. (*F. A. Maclang*), 2 ♀♀. Apparently endemic in southern Luzon, where it is fairly common on Mounts Maquiling and Banahao.

ECTENUS AEREUS Stål

Stål, Öfversigt Kongl. Vetenskaps.-Akad. Förhandlingar (1870) 621.

BOHOL, May 1906 (*A. Celestino*) ♀. Card says "Cerambycidae". MINDANAO, Agusan River, Dec. 27, 1909 (*A. Celestino*), 1 ♀, October 1, 1910 (*Schultze*), ♀ ♀; Davao; November, 1911 (*C. M. Weber*, 1 ♂; September, 1911 (*C. M. Weber*); ♂ BILIRAN, North of Leyte, Naval, 1914 (*McGregor*), 1 ♀.

ECTENUS BREVIROSTRIS Stål

Stål Öfversigt. Kongl. Vetenskaps. Akad. Förh. (1870) 622.

This species was not included in the collection before me. It is known only from Stål's type specimen, which, according to Prof. Dr. O. Lundblad (*in lit.*, October 18, 1948), is extant in the Royal Natural History Museum of Stockholm. According to the same informant, the type locality is Manila. "Manila" in Stål's time was loosely used by European authors to denote the Philippines; not necesarily any definite collecting locality. No authentic capture of any species of *Ectenus* has ever been made in Manila.

Because my pertinent references were destroyed in 1945, I have been unable to recheck the literature on this species. I am, therefore, indebted to my friend, Prof. Robert L. Usinger, the well-known hemipterologist of the University of California at Berkeley, who very kindly transmitted to me from London (September 14, 1948), the following helpful information:

"Curiously enough, *brevirostris* Stål is not mentioned, even in synonymy, with other species treated by Stål in Enumeratio Hemipterorum, part V, p. 43. This is quite surprising, since he mentions *æreus* which was described in the same publication [*supra*] on a previous page in 1870. . . Unfortunately, the species is not represented in the British Museum collection. . . .

"Stål does not number *brevirostris*—but treats it after '2. E. *æreus* Stål. . . .' Following the description of *æreus* he says, 'Specimen unum divergit rostro breviore, apicem segmenti tertii ventris haud vel paullo superante, articulo tertio quarto dimidio longiore, sulco ventris breviore vel posterius obsoletiore. An species distincta, *E. brevirostris* Stål' "

Since the completion of the present manuscript, a set of Stål's *Enumeratio Hemipterorum* and also Stål's *Hemiptera insularum philippinarum* were received in the library of the College of Agriculture through the courtesy of the Kungl. Vetenskapsakademiens Bibliotek, Stockholm.

ANOMALOUS SECONDARY GROWTH IN SOME ROOTS OF HYDROCOTYLE ASIATICA LINNÆUS

By Dhirendra Nath Chakraverti
Botany Department, R. G. Kar Medical College, Calcutta
(Formerly Carmichael Medical College, Calcutta)

TWO PLATES

INTRODUCTION

In the present paper the writer records the result of detailed investigation of anomalous secondary growth in some roots of *Hydrocotyle asiatica* L. (the Asiatic Pennywort) of the family *Umbelliferae,* a preliminary account of which was published some time back.[2] The anomaly consists in the fission of the vascular cylinder into numerous discrete vascular bundles at the base of some roots of this plant. This stoloniferous herb is common in Bengal and is found in all parts of India at altitudes up to 2,000 feet, its distribution being tropical and subtropical (Hooker).[7]

Naked eye observations of the roots do not, as a rule, show any indication of the fission of the vascular cylinder inside the same but in some cases the cleavage may be inferred from a slight wavy outline or a little flattening of the root itself.

MATERIAL AND METHODS

For microtome sections the selected roots were cut into bits from the base to the tip and fixed in three lots: the first in stock chromo-acetic solution, the second in 'CrAF,' named by Randolph [13] and the third in formalin-water (40 per cent formalin 10 cc and distilled water 90 cc) at 60° C. for 2 hours. Specimens killed and fixed in the first fixative were treated in the usual way; those of the second lot were directly immersed in 75 per cent alcohol, then passed through the alcohol grades, dehydrated, cleared in cedar-wood oil and embedded as usual; and the last lot, fixed in formalin-water, was treated directly with 95 per cent alcohol for 1 hour, then passed through pure dioxan, 2 changes of 1 hour each, dioxan-paraffin (1: 1) 1 hour, paraffin 2 changes of 15 to 20 minutes each, and finally embedded according to Chapman's [1] review of T. Garvin. All the fixatives proved equally successful. Serial microtome sections were cut

in transverse plane 8 to μ to 19 μ thick from the base of the root towards its apical part and some longitudinal sections were also made for comparison. Delafield's haematoxylin and (rapid) safranin as suggested by Dean,[4] safranin and light green dissolved in clove oil and Bismarch brown and light green were used. The first combination gave the best result.

For the microscopical examination of the cleft xylem-mass *in situ*, a few roots were decolorised after Debenham[6] in 60 per cent lactic acid for some days, washed in 75 per cent glycerine for 2 to 3 days, then treated with 50 per cent alcohol to ensure complete washing out of the acid and glycerine used. The materials were afterwards bleached in Eau-de-javelle at 40° C. for about 15 to 20 minutes followed by a thorough washing in water for 12 hours with several changes and then treated with 10 per cent alcohol; the roots were then stained as a whole without any sectioning. The writer, however, got equally good results by gently boiling the materials in 60 per cent to 80 per cent lactic acid solution over water-bath for 2 to 4 hours according to the thickness of the roots. After the first hour's boiling some more lactic acid solution was added at intervals to maintain the uniform strength of the boiling solution. This hastened the preliminary decolorization without any perceptible injury of the materials and was a time-saving modification, at least in these materials. Free-hand sections from the base, middle and apical regions of many of these roots were also examined mostly mounted in dactic acid.

OBSERVATIONS

The fission of the xylem-mass is found confined to the base of some roots of 1 to 3 mm in diameter, within a space of about 3 cm from the point of their origin; beyond this the nature and arrangement of the xylem-masses are normal up to the tip. The fission occurs, generally, only once in the root but very rarely, a second fission is also noticed in the same root. On examining the serial microtome sections from the neighborhood of the tip region the apical region shows radial arrangement of the vascular bundles, which may be three, four (Pl. 2, fig. 1) or five in number in different specimens. The pith is distinct, parenchymatous and thin-walled. In the apical region of some young roots the pericycle has been found to be 2 to 3 layers thick (Pl. 2, fig. 1) but in other older roots the pericycle has become 3 to 4 layers in thickness. The major portion of the root shows

secondary growth and thickening of the dicotyledonous type. In adult roots, in many cases, the center is occupied by metaxylem elements (Pl. 2, fig. 2).

In the middle portion of the root, the cambium approximates a circular ring which towards the basal region becomes progressively invaginated towards the center between the consecutive xylem bundles (Pl. 2, figs. 2, 3, 3a and Pl. 1, fig. 2). Ultimately, it breaks up into as many separate arcs as there are primary xylem bundles. Each of these separate cambial arcs then extends round and encloses the primary xylem with some amount of secondary wood in an annular manner (Pl. 2, figs. 4 and 4a). The smaller ring of cambium, thus formed, then produces at its sides and towards its center, a large amount of parenchymatous cells, arranged in regularly widening circles which push apart the original xylem-masses laterally from one another and force them away from the center, thereby causing the cleavage or fission of the original xylem-mass (Pl. 1, figs. 1 and 2). In the absence of such cambial growth the xylem-masses would have formed a continuous cylinder. This fission causes a slight flattening or wavy outline of these roots as already mentioned earlier. The xylem parenchyma is found abundantly between the cleft xylem-masses and also in the secondary wood.

The old roots in general show copious development of parenchyma. The primary medullary rays at the back of the protoxylem widen gradually towards the cortex to form somewhat funnel-shaped medullary rays (Pl. 1, figs. 1 and 2). The primary phloem bundles, composed of thick-walled cells, are situated at the outer end of the broad radially elongated medullary rays alternating with the primary xylem bundles (Pl. 1, fig. 2). The secondary phloem bundles are collateral, often truncated, conical in shape and are separated from one another by the widening medullary rays. Sometimes, the walls of these secondary phloem bundles are thickened but they give cellulose reaction. Starch grains are found deposited in abundance in all the parenchymatous elements within the stele (Pl. 1, fig. 2); calcium oxalate occurs very rarely as sphaeraphides in some parenchymatous cells (Pl. 2, fig. 5.)

The cortex is gradually exfoliated from the old roots (Pl. 1, fig. 2), but in the younger ones the cortical cells are found very loosely arranged with broad air-spaces (Pl. 1, fig. 1). Phellogen appears in the pericycle after secondary growth (Pl. 1,

fig. 2, and Pl. 2, fig. 5) and the continuity of the endodermal layer is interrupted, its cells becoming flattened in the meantime (Pl. 1, fig. 5). Glandular ducts are found opposite the xylem and the phloem groups of the primary vascular strands (Pl. 2, fig. 1) as noted by Solereder.[14] After the secondary growth such ducts are also seen external to the secondary phloem (Pl. 1, figs. 1 and 2; and Pl. 2, fig. 5).

A somewhat similar fission of the xylem-mass was reported by Koch [11] in the mature napiform roots of *Sedum maximum* Sut. of the family *Crassulaceae* and its allies, the difference being that in this case the fission occured in the middle portion instead of the basal region of our roots and the bundles were hadro-centric instead of the collateral ones as are found in the roots of *Hydrocotyle asiatica* L.

The fission of the xylem-mass in the root of *Hydrocotyle asiatica* L. differs in many ways from that of *Azorella selago* Hook. f. as noted by Ternetz,[15] although the two genera belong to the same sub-family *Hydrocotyloideae* under the family *Umbelliferae*. In *Azorella* disorganization of the ground tissues of the secondary cortex takes place and is followed by the cleavage of the xylem-mass. Here a meristematic tissue originates secondarily in the parenchyma bordering the cleft places whereas in the roots of *Hydrocotyle*, disorganization of the parenchymatous ground tissue has not been observed nor any new meristem has been found to develop anywhere. In *Hydrocotyle* the conducting cylinder of the root splits up into as many segments as there are primary xylem bundles and all these separate strands, thus formed, are found arranged in a regular ring unlike the innumerable, irregularly scattered vascular strands of *Azorella*.

The anomalous root structure of *Oenanthe*, *Magydaris* and *Myrrhis* of the same family (*Umbelliferae*) is, however, of a quite different nature (Solereder).[14] Fission of the xylem-mass in roots of plants belonging to other families has also been reported from time to time. Dastur and Kapadia [3] have observed the fissoin of xylem caused by the dilatation of parenchyma in the aerial and the underground roots of *Tinospora cordifolia* Miers. (Family *Menispermaceae*). Recently, P. C. Joshi [10] has noted the splitting up of the stele of the old stems and roots of *Thylacospermum rupifragum* Schrenk., a Tibetan *Caryophyllaceous* plant, into numerous irregular vascular strands. A. C. Joshi [9] has reported a somewhat similar anomaly in the roots of another Tibetan plant, *Stellera chamae-*

jasme L. of the family *Thymelaeaceae.* Solereder [14] records the occurrence of the cleft xylem-mass in the stems and in some cases in the roots also of some plants belonging to the families *Caryophyllaceae, Malpighiaceae, Sapindaceae, Caesalpinieae* (*Bauhinia*), *Umbelliferae, Asclepiadeae, Convolvulaceae, Bignoniaceae, Acanthaceae* and *Aristolochiaceae.*

DISCUSSION

In great many cases secondary differentiation of the stelar tissues of the dicotyledonous roots has been found to deviate more or less considerably from that of the normal type. All stages, from the simpler cases of the unequal growth of the xylem through its furrowed appearance to the splitting up of the vascular cylinder into separate strands have been observed in a number of families by different authors. The segments, so formed, may be arranged simply in a regular ring as in the roots of *Hydrocotyle,* or by repeated cleavage and secondary growth they may produce masses of wood and bast irregularly interwoven with one another as in *Azorella.* Such anomalous vascular structures have also been observed in the stems of some tropical lianes belonging mostly to the families of *Combretaceae, Malpighiaceae* and *Bauhineae* (De Bary).[5] Another type of cleavage has been noted by Lashevsky [12] in the underground stems of *Daphne julia* (Family *Thymelaeaceae*) where the fission is caused by the activity of the parenchyma of the pith, wood and wood-rays. The cause of these anomalies has, however, not been satisfactorily explained. Lashevsky thinks that this is an ancestral character retained by the species showing the anomaly but in the present case, as in all others, where great parenchymatous development with abundance of starch grains as the cell-contents is the consequence of such cleavage, the explanation put forward by Haberlandt [7] appears to be very reasonable. He maintains that such peculiarities of secondary growth serve to ensure the production of the storage tissue characteristic of the roots of many *Umbelliferae,* rendering the deposition and renewal of reserve materials easier and more effective after the intermixing of the conducting and the storage tissues.

SUMMARY

1. The roots of *Hydrocotyle asiatica* L. show usually normal secondary growth and thickening characteristic of the dicotyledonous root with a great tendency towards the development of the parenchymatous tissues.

2. In some roots, however, the vascual cylinder at the basal region split up into numerous discrete vascular strands, their number being the same as the number of the primary vascular bundles of the root. Here the continuous cambial ring becomes progressively invaginated towards the center of the root and breaks up into separate arcs, each one of which ultimately encloses a xylem-mass including one primary xylem bundle.

3. The fission of the vascular cylinder is probably due to the tendency of the development of storage parenchyma, thus rendering the deposition and renewal of food materials easier and more effective in the roots.

In conclusion, I desire to express my grateful thanks to Dr. S. R. Bose, Professor of Botany of this College, for his valuable help and criticisms in this investigation.

LITERATURE CITED

1. CHAPMAN, G. H. The use of dioxan in histological technique. Stain Tech. **14** (1939) 113.
2. CHAKRAVERTI, D. N. A preliminary note on the fission of vascular cylinder in some of the roots of *Hydrocotyle asiatica* Linn. Curr. Sci. **9** (1940) 230–233.
3. DASTUR, R. H. and G. A. KAPADIA. The anatomy of climbing plants, Jour. Ind. Bot. Soc. **10** (1931) 110–121.
4. DEAN, H. L. Delafield's haematoxylin and safranin for staining plant materials. Stain Tech. **15** (1940) 61–65.
5. DE BARY, A. Comparative Anatomy of the Phanerogams and Ferns. Oxford. (1884).
6. DEBENHAM, E. M. A modified technique for the microscopic examination of the xylem of whole plants or plant organs. Ann. Bot. N. S. **3** (1939) 369–373.
7. HABERLANDT, G. Physiological Plant Anatomy. London. (1914).
8. HOOKER, Sir J. D. Flora of British India **2** (1879) 669.
9. JOSHI, A. C. Secondary thickening in the stem and root of *Stellera chamaejasmae* L. Proc. Ind. Acad. Sci. **2** (1935) 424–436.
10. JOSHI, P. C. Anatomy of the vegetative parts of two Tibetan *Caryophyllaceae—Arenaria musciformis* Wall. and *Thylacospermum rupifragum* Schrenk. Proc. Ind. Acad. Sci. **4** (1936) 52–65.
11. KOCH, L. Entwickl. d. Crass. Verh. naturhist.-med. Ver. zu Heidelberg. Bd. **1**, 4 Helt. (1876).
12. LASHEVSKY, V. On the liane structure in the subterranean stem of *Daphne julia*. Bot. Abstracts, April–May (1926).
13. RANDOLPH, L. F. A new fixing fluid and a revised schedule for the paraffin method in plant cytology. Stain Tech **10** (1935) 95.
14. SOLEREDER, H. Systematic Anatomy of the Dicotyledons. Oxford (1908).
15. TERNETZ, Ch. Morphol. u. Anat. d. *Azorella selago* Hook. f. Bot. Zeit. **60** (1902) 1–20 und Tab. 1.

ILLUSTRATIONS

(Explanation of the abbreviation of the parts labelled in the figures is given at the end. Figures of Plate 1 are photomicrographs and those of Plate 2, are camera lucida drawings from the roots of Hydrocotyle asiatica Linn.)

PLATE 1

FIG. 1. Transverse section of a root showing earlier stage of the formation of cambium ring around each xylem-mass including one primary xylem. A cork-cambium is forming in the pericycle. The cortex is in process of sloughing off especially in the lower side. (Eye piece 7.5 X and objective 16 mm.)

2. Transverse section from the base of an old root showing four discrete xylem-masses arranged in a ring. Pericycle 3 to 4 layered showing phellogen outside. Endodermis interrupted at places. Cortex and epidermis completely sloughed off. (Eye-piece 5 X and objective 16 mm.)

PLATE 2

FIG. 1. Transverse section from the apical region of a young root showing tetrarch arrangement of vascular bundles and 1 to 3 layers of pericycle. X 430.

2. A portion of the transverse section from the middle region of an adult root after secondary growth showing the invaginating cambium and the metaxylem elements meeting at the center. X 450.

3. Transverse section from the basal part of an old root giving semi-diagrammatic view of the normal circular cambium becoming progressively invaginated towards the center. Also it shows among other parts a space within for 3 to 4 layered pericycle the inner limit of which has been shown in a circle of dots. X 80.

3*a*. One of the three xylem bundles of Fig. 3 showing details of a portion within the invaginated cambium and a portion of the primary medullary ray outside. X 430.

4. Semi-diagrammatic view of the root in transverse section showing the formation of a complete ring of cambium round each xylem-mass. The continuity of the endodermis is found interrupted at several places of the section. Just below this phellogen is shown in circular outline in dots. The innermost three small circles in dots represent the outer limit of the discrete vascular bundles. The bigger circle in dots enclosing the three separate vascular bundles is the inner limit of pericycle which is 3 to 4 layers of cells in thickness. X 70.

4*a*. One of the three xylem-masses of Fig. 4, shown in details. Here a few cells of the basal part of the primary medullary rays have been shown just opposite to protoxylem. X 440.

5. Drawing of an outer part of Pl. 1, fig. 2, showing interrupted endodermis, phellogen, glandular ducts, sphaeraphides, etc. X 430.

ABBREVIATIONS USED

a—air-space
c—cortex
cam—cambium
dvb—discrete vascular bundle
e—epidermis
en—endodermis
gd—glandular duct
mr—medullary rays
mx—metaxylem
p—pith cells
pc—pericycle
ph—phloem
phl—phellogen
pph—primary phloem
ptx—protoxylem
px—primary xylem
sg—starch grains in parenchymatous cells
s ph—secondary phloem elements
sx—secondary xylem elements
x—both the primary and secondary xylem elements
xp—xylem parenchyma

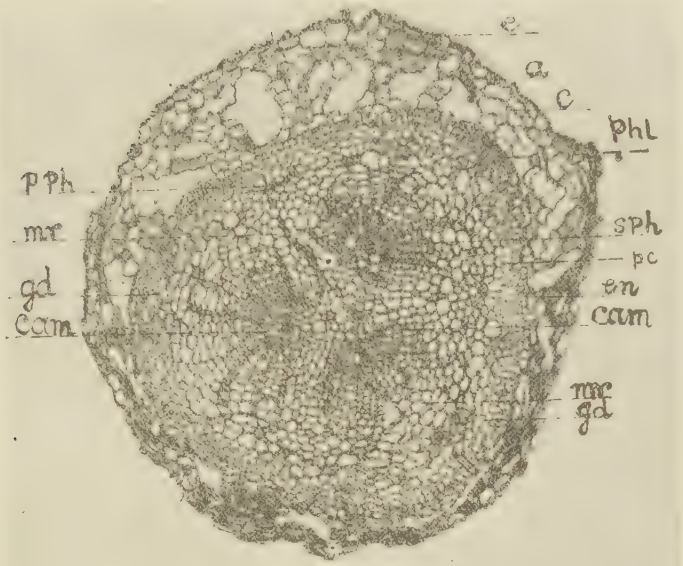

Fig. 1

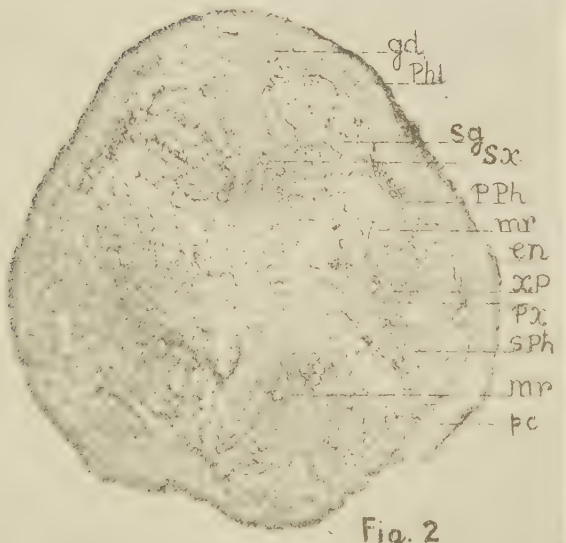

Fig. 2

PLATE 1.

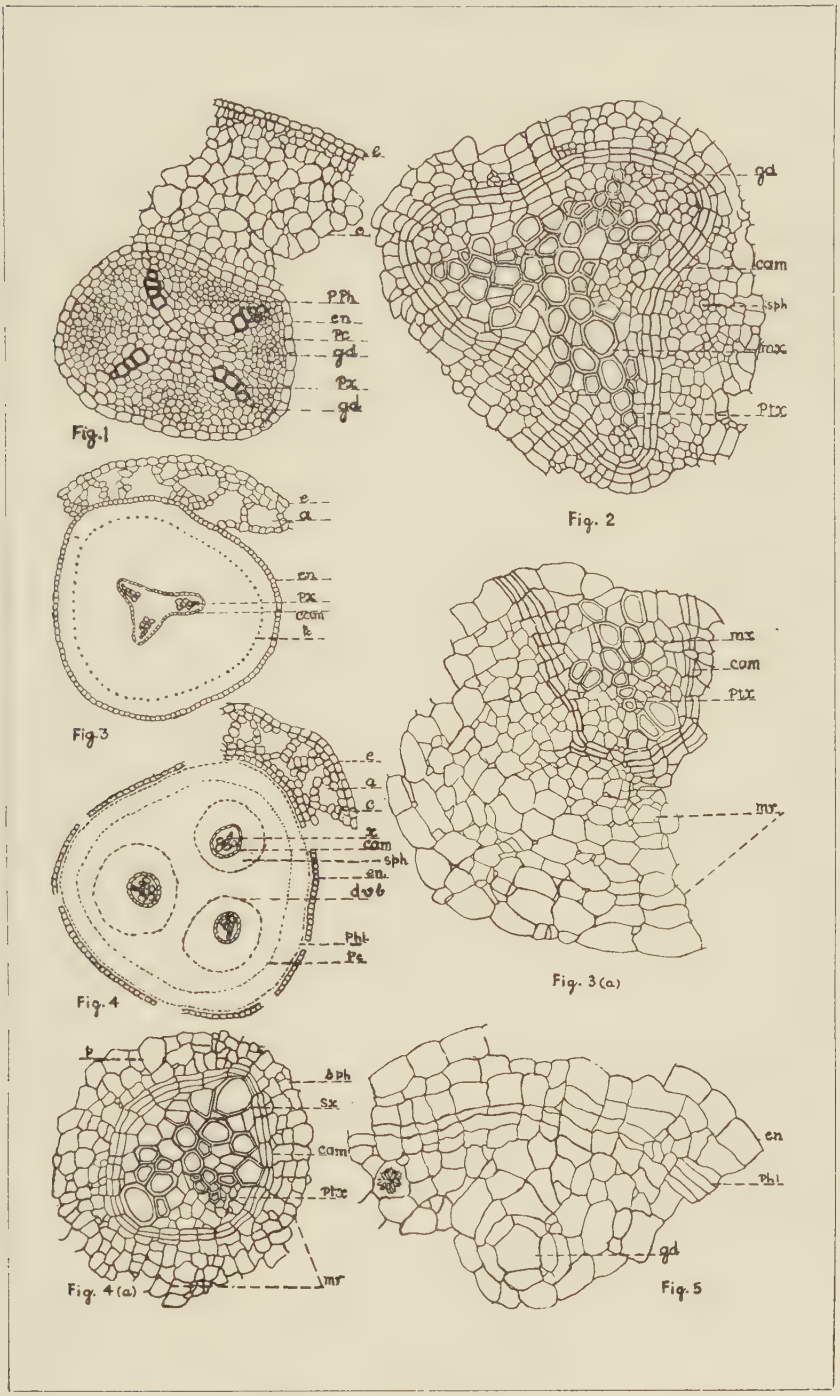
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Fig. 5

PLATE 2.

THE CAROTENE CONTENT OF THE FRUIT OF MOMORDICA COCHINCHINENSIS SPRENG

By H. A. Boekenoogen
Director of the Unilever Research Laboratorium
Zwijndrecht, Holland

During the "Journées scientifiques des corps gras alimentaires" held in April 1949 in Paris Dr. Autret of the "Centre National des Etudes et Recherches sur la Nutrition et l'Alimentation" recorded the extremely high content of carotene in the fruits of *Momordica cochinchinensis* Spreng, called by the Annamites "day-gac". According to the minutes of the meeting in Oléagineux, **4**, (1949) 309, 8 grams of carotene could be found in 1 kg (0.8 per cent). Further details will be published by Autret in the same journal.

As we are keenly interested in materials with a high carotene content, the investigation of this remarkable fruit was of great value and we succeeded in getting this fruit—carefully sealed in beeswax—from the Philippines.*

The fruit resembles in shape a great pear and in color an orange. The weight was about 300 grams. On first sight our attention was drawn by the deep red layer surrounding each of the 14 black seeds within the fruit pulp. According to the Carr-Price reaction this layer contains carotenoids, but analysis showed that carotene itself was present in only a small quantity.

The fruit was divided in four parts and the total carotene content of each determined:

	Weight	Per cent of total	Carotene	Per cent
a. Skin	46 g.	16	1.62 mg.	0.004
b. Fruit pulp (pale yellow)	198 g.	67	0.82 mg.	0.0004
c. Pulp round seeds (blood red)	20 g.	7	0.83 mg.	0.004
d. Seeds (black)	31 g.	10	----------	----------
Total	295 g.	100	3.27 mg.	0.0084

* We are very grateful to Dr. Eduardo Quisumbing, Director of the National Museum in Manila, Mr. Kenneth B. Day, Director, and Mr. G. J. Wouters, Asst. Technical Director of the Philippine Refining Co., Manila, for all the trouble taken in sending this fruit to Europe in a fresh condition.

The results are nearly negative, and we see once more that people are often attracted by the deep red color of some fruits, but that this is not always the sign of a high content of provitamin A in the form of carotene.

From these results we may conclude that Autret's statement must be based on an error, probably caused by the deep red color of the pulp. The coloring matter was not further investigated because the carotene content showed to be in no way abnormal.

SCYLLA (CRUSTACEA: PORTUNIDÆ) II. COMPARATIVE STUDIES ON SPERMATOGENESIS AND OÖGENESIS *

By Eulogio P. Estampador
Iloilo College, University of the Philippines, Iloilo City

FOURTEEN PLATES

MALE ORGANS

The genital systems of the four groups, namely, *Scylla serrata* (Forskål) ; *S. serrata* var. *paramamosain* Estampador; *S. oceanica* (Dana) and *S. tranquebarica* (Fabricius), do not show marked differences in their gross morphological features. Hence, the following general description will serve for all.

The abdomen of the male (Plate 2, fig. 1) is much narrower than that of the female, and is provided with only two pairs of appendages which are modified as copulatory organs. The external genitalia consist of a pair of tubules or ducts, which are about eight millimeters long in a crab that measures nine centimeters across the widest portion of the carapace. Each duct comes out from an opening at the base of the thoracic leg, and is received into the troughlike excavated area (*cisterna spermatica*) on the inner surface of the base of the terminal joint of the first abdominal appendage.

The first abdominal appendage (Plate 2, figs. 2, 3) is composed of two joints; the basal one is broad, rectangular, and flattened on its inner surface, which is held appressed to the sternal wall. The terminal segment has a sinuous outline; it is long and tapering with the point shaped like that of a quill pen or that of a hypodermic needle. The cisterna spermatica (Plate 2, fig. 2 *c*) apparently functions as a receptacle to receive the sexual products expelled from the ejaculatory duct. From this cistern a canal leads ventrally, that is, towards the outer surface and to the mouth of the funnel-tube—the remaining portion of the last segment, which is so constructed as to present a semblance to a slender funnel. Indeed, its structural peculiarities and its relations with the ejaculatory duct point to its probable function of transferring spermatozoa into the vulva of the female in copulation.

The second abdominal appendage (Plate 2, fig. 4) is a delicate, unsegmented structure. In the same animal, it measures thir-

* Pt. I. Revision of the Genus, Philip. Jour. Sci., 78 No. 1 (1949) 95–109.

teen millimeters in length, and hardly one millimeter in diameter at the base of the fork. One branch of the fork is spooned and provided with spinules; the outer branch (*c*), which contains a troughlike cavity, is inserted into the opening of the funnel-tube of the first appendage.

During copulation, the ejaculatory duct pours the male sexual products into the cisterna spermatica which is connected to the opening of the funnel-tube by a canal. The forked rodlike second abdominal appendage presumably helps by keeping the spermatophores confined in the funnel-tube, in forcing the male sexual products into the vulva of the female.

The testes (Plate 2, fig. 6) are paired and symmetrical. The two halves are connected immediately behind the foregut in almost the same situation as the ovaries in the female. They are symmetrical in position and lie immediately beneath the hypodermis. The size and shape vary with the condition of sexual maturity of the crab. They are small in immature specimens; while in sexually mature individuals, during the spawning season, they are massive, practically filling up the angular space between the carapace and the sternal wall, and may cover up almost the whole of the digestive gland. Each testis describes an arc following the outline of the carapace; the terminal portion extending as far as the postero-lateral teeth.

At the inner extremity, at about the region of the cardiac foregut, it dips inward and behind the pyloric foregut, it forms a prolongation that joins a similar portion from the other testis forming a sort of a bridge. Posterior to this bridge, it connects with a very much coiled tube, the vas deferens. At the point just above the level of the pyloric foregut, the duct turns inward and follows the course along the digestive tract. It becomes narrower and continues backward to the base of the last thoracic leg, where it empties into the exterior through an opening on the coxopodite of the last leg. We shall call this portion the ejaculatory duct. This is protected by the extension of the arthrodial membrane from the base of the leg, the membrane rolling around it at the terminal portion. The duct lies closely appressed to the sternal wall and is covered by the lateral extension of the third segment of the abdomen. Its tip is received into the opening of the funnel-tube of the first abdominal appendage.

There are several factors which presumably lead to the expulsion of the sexual products into the funnels tube. Undoubtedly,

gravity plays an important rôle. So does pressure; this may arise from two sources, namely, internal and external. The first, we may qualify as the transmitted pressure which operates in the same manner as in a water-main. Pressure from outside is brought about by the movements of the copulatory apparatus during mating. In these movements, the ejaculatory duct is caught in between the sternal wall and the lateral extension of the wall, the cisterna spermatica. Other factors may be sought in the structural constitution of the duct itself. The epithelial cells that line the cavity of the ejaculatory duct are glandular and ciliated (Plate 2, fig. 7). Obviously, they produce some kind of secretion, the nature of which is not known at present. The cilia, of course, help in the movement of some metabolic products in the duct.

As in the ovary, the testicular follicles are closely packed together. The lumen of each follicle is continuous with that of the vas deferens. The cells that line the lumen are of three types, namely, the spermatoblast, the nurse cells, and the secretory cells. The last are probably collagen-forming cells.

The spermatoblasts are easily distinguished by the large amount of cytoplasmic materials present and by their large nuclei. The nurse cells are smaller, with distinctly smaller nuclei, and are more or less vacuolated. In both of these kinds of cells, the nuclei are basal in position.

The secretory cell is big, rounded in outline and possesses a big vesicle. Its metaplasm takes up a bluish tint with iron hæmatoxylin, acid fuchsin and anilin blue stain combination; the secretory product is apparently collagen or a related substance. The secretory cells present in the follicles are very much fewer and are smaller, compared to those present in the ovarian follicles (Plate 7, fig. 9).

The secretion presumably furnishes the necessary medium for the spermatozoa on their way to the outside. If such be the case, this medium must possess a certain degree of viscosity to protect the spermatozoa from the action of the water. In the case of the female, the secretory cells furnish the sticky material by means of which the eggs are attached to the endopodite setæ. Considering the large number of eggs and their relatively much bigger size, a considerably much greater amount of material is needed. Perhaps this fact may explain the presence in greater number of secretory cells in the ovarian follicles.

SPERMATOGENESIS

The spermatoblasts (auxocytes) may proceed in their development either singly or in groups. In either case, the growing auxocyte draws some of the cytoplasmic and nuclear materials from the surrounding cells and uses them for its growth. In the case where they are in groups, the competition among themselves results in some being used up by the more vigorous auxocytes. The group is held together by a sort of cyst, probably formed from the detritus from the used-up cells, and possibly cemented together by the secretion of the secretory cells. Such a group of auxocytes may be termed spermatocyst (Plate 5, fig. 1 and Plate 6, fig. 6). This group formation is frequently met with in the *mamosain* and *paramamosain* groups, and occasionally in the *parabanhawin* (*S. tranquebarica*). It does not seem to occur in the true *banhawin* (*S. oceanica*).

The most distinctive changes that take place during the growth of the auxocyte can be observed in the increase of its bulk due to the increase in volume of its cytoplasm and in the increase in size of the nucleus. At the termination of the growth period, the cell undergoes transformation in two distinct ways; one, the whole cell, or the greater portion of it, participates actively; the other, the apparent activity is seemingly centered around the nucleus and the rest of the cell undergoes no radical structural changes, except for the sloughing off of the cytoplasm.

Heteropycnosis.—A very peculiar characteristic is seen in what is termed "heteropycnosis," in which the sex-chromosomes become greatly condensed and form an intensely staining mass, appearing as a karyosome, or "chromosome-nucleolus," in sharp contrast to the threadlike or diffused and slightly staining ordinary chromosomes. It appears to be a very conspicuous feature during the growth period and, in some cases, it appears even as late as in some phases during spermatid-transformation (Plate 5, figs. 4, 5).

This condensed mass of chromatin materials give rise to the "hetero-chromosomes" of some authors. Among the groups of crabs under consideration, the chromosome-nucleolus represents either the XX- or the XY-pair of chromosomes.

Spermiogenesis.—After the growth period, the cell undergoes a series of transformations; the subsequent developmental phase may be termed "spermiogenesis" or "spermioteleosis." In *S. tranquebarica* (*parabanhawin*) and in the variety *paramamosain*, the process of spermatogenesis can be subdivided quite

distinctly into four general phases, namely, (1) the auxocyte, characterized by growth, (2) the pro-spermatid stage, characterized by reorganization, differentiation, and sloughing off of some of the materials leading to the formation of the definitive spermatid body, (3) spermatid transformation, also featured by reorganization, differentiation and further sloughing off of the materials, and (4) the spermatozoön. While in *S. oceanica* and *S. serrata* the four general phases cannot be distinctly differentiated, there is a considerable merging of these phases; hence, an apparent shortening of the process of spermatogenesis.

SPERMIOGENESIS IN S. TRANQUEBARICA

This group is described first, because the two types of spermiogenesis previously referred to occur in a somewhat more elaborate manner. The two types are linked with the chromosomal constitution of the germ cells involved: (1) in one class, there is tetrad formation and almost the whole of the cell actively participates; (2) in sharp contrast to the other class, the apparent activity is seemingly centered in the nucleus. We shall refer to the first as having the tetrad formation and to the second as without tetrad formation.

I. *Spermiogenesis in cells having tetrad formation.*—In this class the process involves telokinetic movements which include: (1) movements of the nucleus, (2) extrusion of some of the nuclear materials and most of the cytoplasm, (3) peculiar behaviour and movements of the acroblast, (4) rotation of the chromosomes. This phenomenon is especially noticeable in the hetero-chromosomes.

Some of the more obvious changes that take place in the series of transformations leading to the formation of spermatozoa may be seen in the following illustrations:

Plate 3, fig. 1, represents a growing auxocyte. Within its body, the shriveled nucleus of a nurse cell can still be seen. Its nucleus is apparently in the leptotene-stage, the spireme threads beginning to arrange side by side, evidently in preparation for synapsis (syndesis). The tetrad formation is quite obvious; this is shown by a loop giving rise to four chromatids. It seems that in this case synizesis is foreshadowed by a migration of the prochromosomes towards certain places along the periphery of the nuclear wall, where they become closely aggregated before the leptotene threads are spun out from them. The biggest of these pre-sinizetic knots apparently give rise to the hetero-chromosomes.

Plate 3, fig. 2, shows the surface view of an auxocyte at the termination of the growth period. Evidently, it is in the contraction phase; the chromosome-nucleolus is at the center, and from it, the prochromosomal threads radiate, apparently in pairs.

Plate 3, fig. 3, depicts a pro-spermatid body, wherein the process of concentration is going on, apparently in preparation for the subsequent reorganization. From this point on, the subsequent changes that follow are not those of growth, as these are characterized by diminution of the size of the cell accompanied by reorganization and differentiation. The term spermatocyte does not seem to fit in this particular case, taking into consideration the previous history, and the changes that are to follow. In this figure, the spireme has been transformed into chromatids. The tetrad formation is indicated by the grouping of chromatids into four. Though in a somewhat diffuse condition, the arrangements in pairs is quite apparent as in (1) in which each mate is composed of a row of chromatids. Presumably this pair will form in synapsis an anaschistic rod tetrad with terminal connection.

Plate 3, fig. 4, shows the chromosomes in pre-synaptic associations; the pairs are recognizable. Three types of tetrads are present: (1) the loop-shaped, which is apparently the X-chromosome in the XY-pair, the hetero-chromosomes (*h*); (2) rod-like; and (3) V-shaped. Some of the chromosomes are distinctly segmented.

Plate 3, fig. 5, shows the synaptic figures; the mates of some differ in size, form and in structure. Hence, they are heteromorphic. In the attraction sphere or idiosome (*i*) are darkly stained bodies with granular constitution; these are the pro-acrosome granules (*p. ac*).

The changes that bring about the transformations leading to the formation of spermatozoa are featured by series of concentration, contraction, and diminution of both the nuclear and cytoplasmic materials. Some of the phases of spermatid transformation are illustrated in the following figures:

In Plate 3, fig. 6, the pro-spermatid body has assumed a more definitive form, its outline has become more regular. The chromatin net-knot (nucleo-chromosome) appears as a big heavily stained body near the center; the rest of the chromatin materials have ranged along the border of the nuclear wall toward the apical pole as small deeply stained masses, while some are

apparently being sloughed off at the opposite pole. The darkly stained mass (*n. e*) is presumably composed of extruded nuclear materials; the other (*g*) containing heavily stained bodies probably constitutes extruded Golgi-remnant bodies. The picture shows clearly the process of diminution involving the cytoplasm and the karyoplasm. The attraction sphere or idiosome (*i*) is now at the apical pole and contains a heavily stained body, the *acroblast* (*ac*).

Plate 3, fig. 7, depicts the process of concentration, as evidenced by the broken and reticular condition of the cytosome at the basal portion of the pro-spermatid body. The nucleus has moved farther toward the apical pole; the chromosomes are now dyads, instead of tetrads, and the number has been reduced to six. The small U-shaped chromosome near the pole is evidently the extra sex-chromosome (*m*). It behaves differently by moving ahead of the others. Reduction of the amount of the chromatin materials and, consequently, the number and size of the chromosomes must have taken place in the preceding stages. This reduction was brought about by a sort of regrouping or seggregation of the chromosome materials—the tetrads separating into dyads without undergoing division in the usual manner. One of the groups, evidently composed some of the nuclear materials that were cast off (Plate 3, fig. 6, *n. e*).

Plate 3, fig. 8, shows the differentiation of the definitive spermatid body (*sp. b*). The nuclear materials have reached the proximity of the attraction sphere; presumably the heavily stained body in the form of a nucleo-chromatin is the sex-chromosome (*x*). Apparently the acroblast has disaggregated. The spermatid has a form very much like that of a hat; the head is obviously composed of the sphere-substance referred to by Wilson (1924)[4] as a clear substance inside the idiosome; the brim is composed of cytoplasm, and the nucleus is apparently located centrally in this region. This figure indicates clearly that only a small portion of the cytoplasm is utilized in the formation of the definitive spermatid body; the rest is sloughed off. This mass of residual protoplasm (*r. p*) degenerates without taking any further part in the sperm formation. Some of these discarded materials are presumably used in the formation of the cyst, in cases where the auxocytes are in group formation (spermatocyst). The remainder is released into the lumen of the follicle and into the spaces between the follicular tubules, where they are observed as the undifferentiated chro-

mophyllic mass. Some sloughed-off nuclear materials and Golgi-remnant bodies are commonly seen in this mass. The heavily stained mass (*c. e*) among the cast-off materials may represent either nuclear materials or a portion of the cast-off acroblast.

Plate 3, fig. 9, represents a sort of an abortive mitotic figure showing division involving mainly the nucleus. Part of the cytoplasm will undoubtedly go with the casting off of the daughter nucleus. Apparently, this process constitute the second meiosis, and reduces the chromosomes from dyads to monads. The small chromosome which is out of the alignment and nearer the acroblast, is evidently the extra sex-chromosome. It is no longer U–shaped (Plate 3, fig. 7, *m*). The acroblast (*ac*) is again aggregating. From its constitution, the cast-off daughter nucleus appears to be normal; whether it develops into a normal sperm is yet to be proved. There are indications, however, that it might be the case, as can be inferred from the presence within the remains of the auxocyte body of two spermatids or two spermatozoa in close proximity to each other, a condition which seems to be typical.

Plate 3, fig. 10, shows the top view of a spermatid representing a later stage than the preceding. It represents a figure similar to that of a conical lamp shade; the apex is occupied by the idiosome (*i*) containing two deeply stained bodies—the acroblasts, so disposed opposite each other. The process of concentration is going on, as indicated by the condition of the cytoplasm.

The subsequent concentration will result in the sloughing off of some materials, as shown in Plate 3, fig. 11; it also brings the two acroblast bodies together. These bodies do not fuse, however, the more homogeneous one leaning more to the outside of the idiosome. Further concentration and sloughing off of materials, apparently results in one of the acroblasts being pulled down towards the base to become the acroblast-remnant (Plate 3, fig. 12, *ac. r*), which eventually will be cast off.

The other acroblast body is not shown in Plate 3, fig. 12; apparently it has undergone disaggregation, as indicated by the somewhat clear appearance of the idiosome. The figure indicates that the process of concentration is going on. This is subsequently followed by contraction. Plate 3, fig. 13, illustrates this phase, showing the basal portion viewed from below, and the position of the nucleus at the center of the base of the spermatid body. It also shows the chromosomes which are located along the periphery of the nuclear wall.

Further contraction results in the sloughing off of some more cytoplasmic materials. Plate 3, fig. 14, represents a stage that results from the preceding changes. The figure is something like a dome with the nucleus forming the base. Apparently the acroblast is in a state of disaggregation. The subsequent processes of concentration and contraction that follow transform the figure into something resembling a bowl (Plate 3, fig. 15). The acroblast has reaggregated and occupies a position at the border of the idiosome.

In the subsequent phase, the spermatid assumes a conical form (Plate 3, fig. 16) and the acroblast has split into two bodies, of which one moved down toward the base, presumably to become the second acroblast-remnant. It is highly probable, however, that its materials may become finely disseminated and may be used in the formation of the nuclear cup. The other acroblast body remains at the apex, and it may eventually constitute the definitive acrosome body.

The diminution of the cytoplasm is quite obscure from this point on. It seems that in these later stages, in the basal portion wherein the nucleus is located, the surface-tension balance has reached a point which would establish a certain degree of rigidity in this region. Consequently the sloughing off of materials can no longer take place in this area; it is shifted to the lateral surface, where the surface tension has not reached the determinative fixity.

Plate 3, figs. 16 and 17, show this shifting and also that of the position of the definitive acrosome body towards the base. This apparent movement of the acrosome body is possibly brought about by the concentration of cytoplasmic materials which most likely exerts a pulling force and the subsequent contraction produces a further downward shift. Plate 3, fig. 18, illustrates the movement of the definitive acrosome.

Plate 3, fig. 19, shows the spermatozoön; it measures 13 microns in length and a little over 11 microns in diameter at its base. The form is similar to that of a funnel or a conical cup. The nucleus is located at the mouth of the cup; hence, we may call this region the nuclear cup. Forming the rim of the mouth and extending to the conical tip is the capsule, which may be regarded as a sort of a conical enclosure around the sperm body.

From the foregoing observations on the series of changes, featured by diminution of the constituent materials of the spermatid, each time followed by reorganization and differentiation,

it can be said that the spermatozoön is composed of nothing more than concentrated nuclear materials and a certain amount of cytoplasm packed in a conical capsule.

Acroblast and acrosome.—The most conspicuous features in the later part of spermatogenesis concern the appearance of the acroblast and the series of changes that finally lead to its transformation into a capsule. Acroblast is a body or group of bodies derived from the substance of the idiosome and Golgi-bodies and from which arises the acrosome (the capsule in this case). A brief summary of the behaviour and movements of these bodies will serve to portray the rôle they play in sperm formation.

In these crabs (*S. tranquebarica*), the acroblast is at first identified as a group of granular bodies (the pro-acrosome granules) within the idiosome (Plate 3, fig. 5, *p. ac*). The idiosome is composed of a clear substance called by some authors as the "sphere substance." From its position at the side, the acroblast shifts anterior to that of the nucleus and moves towards the apical pole (Plate 3, figs. 5, 6), where it appears as a heavily stained body inside the idiosome. This implies that during interkinesis, the granular bodies have disaggregated and later some portions reaggregated to form the acroblast (Plate 3, fig. 6, *ac*), while the rest is thrown off as the Golgi-bodies remnant (Plate 3, fig. 6, *g*).

In Plate 3, fig. 7, the idiosome bulges out to a conical form; there is no indication of the presence of the acroblast within its area, except for the presence of some fine granules. Obviously the acroblast has undergone disaggregation.

In Plate 3, fig. 9, the acroblast is shown as a group of heavily stained granular bodies near the apical pole. This indicates that, during the intervening phases, the acroblast underwent disaggregation and now it is again undergoing reaggregation.

Plate 3, fig. 10, shows the acroblast as two distinct bodies opposite each other at the periphery of the idiosome. The subsequent contraction that takes place brings these two bodies together (Plate 3, fig. 11, *ac*). With the sloughing off of some of the cytoplasm, the more homogenous body which is leaning more towards the outside of the idiosome becomes detached and sinks towards the base (Plate 3, fig. 12), from where it will be cast off eventually. We shall call this the acroblast-remnant (*ac. r*). The other acroblast body is not seen in this figure; apparently it has disaggregated.

In Plate 3, fig. 15, the acroblast reappears as a heavily stained body at the border of the idiosome. In the subsequent phase, it splits into two bodies, one remaining at the apical pole to become the definitive acrosome body; the other sinking towards the base, perhaps to become the second acroblast-remnant and to be eventually cast off. It is more likely, however, that its materials may become finely dispersed and used in the formation of the nuclear cup (Plate 3, figs. 16, 17).

During the series of concentration, contraction, and sloughing off of materials, the definitive acrosome body migrates nearer to the base (Plate 3, figs. 16, 17); then ultimately disaggregates to become incorporated into the materials that form the capsule of the spermatozoön.

The Capsule.—From the foregoing observations, we can regard the capsule as the structure formed from the idiosome and its sphere substance, together with what is left of the acroblast. Hence, it can be considered homologous with the so-called acrosome in some sperms, since both structures are derived from the same materials.

Cursory examination of Plate 3, figs. 16, 17, and 18 seems to indicate that the direction of the movement of the definitive acrosome body is from the base towards the apical pole (Plate 3, fig. 17). Wilson (1928, p. 381)[4] states: "the most conspicuous feature in the history of the acroblast is its ultimate separation into two parts—one of which moves to the anterior pole and there gives rise to the definitive acrosome, while the other and often larger portion constitutes acroblast-remnant (idiosome-remnant) containing the original Golgi-bodies surrounding the sphere." This seems to be the case only in the early stages.

The observation described by Wilson may really be true for some animals. In these crabs, in the later stages, there seems to be no such movement, because the definitive acrosome is formed in the apical region, the idiosome which holds the acroblast being located in this area. Obviously, the series of reorganization and differentiation involving the acroblast and evidently the idiosome itself must take place in this zone. Hence, in this particular case, the more apparent direction of the movement of the definitive acrosome is from the apical pole and towards the base; whence, it presumably furnishes the material that forms the part of the capsule enclosing the nuclear cup.

Capsule formation in other crabs.—Binford (1913)[2] made the following observations:

> 1. The capsules arise in the cytoplasm as a clear vacuole which may be stained with Lichtgrun. Its contents is gradually changed and have a greater affinity for chromatin stains.
> 2. From a granule on the proximal side of the capsule, the central body develops into the capsule . . . . . .
> 3. The mitochondrial substance is aggregated from the cytoplasm and deposited as a ring between the nucleus and the capsule.

Wilson (1886), Sabater (1893) and Koltzoff (1906) described a similar vesicle which arises in the cytoplasm either against the nucleus or close to it. The vesicle described by Binford and other authors might be the idiosome and the granule referred to, the acroblast.

The observations of the foregoing authors, though made on different crustacean decapods, seem to be in agreement with my assumption that the idiosome and the acroblast form the capsule; it cannot be merely from a vesicle, this term being merely descriptive, indicating a structural feature. The idiosome, on the other hand, has in its make-up something that has active directive influence. Perhaps, it is this unknown factor that influences the transformation of the capsule during the penetration of the sperm into the egg. Binford himself (1913)[2] said: "for the interpretation of the entrance of the spermatozoön into the egg, the transformation of the capsule is more important than the changes in the protoplasmic cup."

II. *Spermatogenesis in the class without tetrad formation* (*S. tranquebarica*).—The mode of spermiogenesis involving cells with no tetrad formation differs markedly in many aspects from that of the class in which there is. In the former, the center of activity seems to be localized in the nucleus and to a very limited area immediately around it. The remaining portion of the cell apparently remains passive. The phases of changes are not so picturesque, and there is an obvious attempt at shortening the period of sperm formation. A brief description of some of the features may help show the differences between these two types of spermiogenesis.

Plate 4, fig. 1, shows a growing auxocyte, drawn from the cross-section of a follicular tubule. As in the auxocytes with tetrads, the characteristic features are: (1) the big nucleus which is basal in position; (2) the greater amount of cytoplasm present, compared with that in the nurse cells; (3) heteropycnosis, that is, the condensation of some chromatin materials

to form the chromosome-nucleolus. The nucleus, however, is relatively smaller in size compared with that of an auxocyte belonging to the class with tetrads.

Plate 4, fig 2, is drawn from the surface view of an auxocyte in a later stage. The chromatin materials are now organized into chromatids. There is no indication of tetrad formation.

Plate 4, fig 3, is drawn from the longitudinal section of the follicle. The condition of the nucleus of the auxocyte indicates that some sort of rearrangement is taking place; perhaps this foreshadows the differentiation of the spermatid body.

In the class with tetrad formation, we differentiate a pro-spermatid stage which subsequently undergoes a series of trans-formations involving the elimination of a considerably large amount of cytoplasmic materials prior to the formation of the definitive spermatid body. On the other hand, in the class with no tetrads this series of changes is omitted; hence, the mode of spermiogenesis differs in that it is somewhat abbreviated.

The chromosomes (Plate 4, fig. 4)) are very much smaller compared with those present in the auxocytes with tetrad formation (Plate 3, figs. 4, 5, and 7). In both classes, however, the chromosomes are segmented. The hetero-chromosome may be seen as V–shaped body (*h*). Besides the relatively smaller size of the chromosomes, another significant difference is in number—there are only five, instead of six, (Plate 3, fig. 13 and Plate 4, fig. 9). This is a case of digamety. The difference in number is due to the presence in the group having tetrads, of an extra chromosome, the *monosome* (Plate 3, figs. 5, 7).

In Plate 4, fig. 5 are shown two spermatids that have differentiated from their respective auxocytes. In (*a*) the acroblast (*ac*) appears as a heavily stained body at the apical pole and the rather large nucleus is at the base. In (*b*) the acroblast has evidently split into two bodies; the one inside the acroblast-vesicle (*v. ac*) within the idiosome will probably form the definitive acrosome body; the other is not shown. No pro-acrosome granules have been observed in this case (Plate 3, fig. 5); the acroblast suddenly appeared as a single chromophyllic body within the acroblast-vesicle. The reticular condition of the auxocyte body may be attributed to the disorganization of the cytosome.

The darkly stained masses (*nc*) are evidently the sloughed-off chromatin materials and the other similarly stained mass (*g*) presumably represents the Golgi-remnant bodies. These masses

have their counterpart in Plate 3, fig. 6. It can be inferred that, with the disappearance of the nuclear wall as the chromosomes are formed, some of the chromatin materials are discarded. In other words, chromatin diminution took place when the spermatid differentiates from the auxocyte body; that is, during the differentiation, and in the reorganization that followed, only so much chromatin material is retained as is proportionate to the cytoplasm of the spermatid body. In other words, the amount of cytoplasm incorporated into the spermatid body determines the quantity of chromatin material that is to be included. This premise, however, does not necessarily preclude the occurrence of a reverse condition. This brings up the question regarding the casual relation between the nuclear volume and cytoplasmic growth—the so-called "karyoplasmic-ratio" of R. Hertwig (1903, 1908, etc.).

The present case seems to be in line with Conklin's observation that "the nuclear volume varies not with the total volume of the cytosome but with that of its active protoplasm." Comparative measurements show a striking correspondence in size between the definitive spermatid body and the nucleus of the auxocyte at the termination of the growth period. The resemblance is such that on cursory examination the spermatid is likely to be mistaken as the nucleus.

This mode of spermiogenesis (in auxocytes without tetrads) was previously described as characterized by the apparent localization of activities in the nucleus including certain limited portion of the cytosome immediately around it. During the differentiation of the spermatid from the auxocyte body, the nucleus underwent reorganization so as to make its mass relatively proportional to that of the active protoplasm which is to be incorporated into the spermatid body. This perhaps accounted for the sloughing off of some chromatin materials.

There are features that yet remain to be explained, such as: (1) In the class that has no tetrad formation, what limit the activities to a very restricted portion of the auxocyte body? (2) Why does the whole auxocyte body take active part in the transformation in the other class (with tetrads)?

Aside from the physical constitution of the chromosomes, the particular phase wherein the two classes differ conspicuously is in the manner by which their respective spermatids differentiate from the auxocyte. Otherwise, in some broad aspects, the other phases of transformation are discernibly parallel.

Plate 4, fig. 6, presumably represents a later phase following the contraction of the spermatid body represented in Plate 4, fig. 5 (*b*). The spermatid body is now elongated and the definitive acrosome occupies a central position within the idiosome at the apical pole, while the acroblast-remnant (*ac. r*) lies at the periphery of the base, eventually to be cast off.

In one of the subsequent phases, a figure resembling a lampshade is formed (Plate 4, fig. 6), with the acrosome body at the apical area. (Cf. Plate 3, figs. 10 and 11, which belong to the group with tetrad formation.)

The next phase is featured by the extension of the apical area to a narrow tip while the base describes a flange at the periphery, (Plate 4, fig. 8).

Plate 4, fig. 9, shows the basal portion of a spermatid. There are five chromosomes. (Cf. Plate 3, fig. 13.)

Plate 4, fig. 10, shows a spermatid in about the last phase of transformation.

The existence of digamety in the sperms of this group of crabs (*S. tranquebarica*) is unquestionably evident. Whether dimegaly also exists at the same time is yet to be proved.

SPERMIOGENESIS IN S. OCEANICA (DANA)

There is only one method of spermiogenesis in this group, in sharp contrast to that in *S. tranquebarica.* Some of the phases of transformation are shown in the following illustrations.

Apparently, after the growth period the auxocyte nucleus splits into two spermatid nuclei (Plate 5, fig. 3). During the subsequent reorganization, some of the cytoplasmic materials around each daughter nucleus become incorporated into the spermatid body (Plate 5, fig. 3). The portion of auxocyte which is involved in the process of spermatid differentiation of the cytosome includes the zones in the immediate vicinity of the spermatid nuclei and the area around the rather enormously large centrosome (*a*), wherein a centriole can be seen at the center.

Plate 5, fig. 5, represents a pair of spermatid bodies that have developed from the spermatid nuclei referred to above. Apparently they are in the contraction phase; the dark condensed chromatin mass, evident in each of them, represents the sex-chromosomes. Each spermatid eventually transforms into a spermatozoön through a series of differentiation and reorganization accompanied by the diminution of both the cytoplasmic and karyoplasmic materials.

That the two daughter spermatid nuclei transform into functional spermatozoa is quite evident. Spermatids in about the same phases of transformation are commonly seen very close together (Plate 5, fig. 5) and spermatozoa in pairs are not uncommon. In this figure the two spermatids had evidently undergone diminution of both cytoplasmic and karyoplasmic materials. Both are evidently in the sinizesis stage.

Plate 5, fig. 6, shows a side view of a spermatid in a later phase. The acroblast appears as a big black mass at the periphery of a rather large idiosome (*i*).

The subsequent contraction splits the acroblast into two portions, one sinking to the base as the acroblast-remnant (Plate 5, fig. 7, *ac. r*), and the other remaining at the apical area as the definitive acrosome body. The figure shows the spermatid from the top, which is narrow, while the base is expanded. The figure corresponds to what we previously termed as the lampshade phase, (in *S. tranquebarica,* Plate 3, fig. 10; Plate 4, fig. 7).

Plate 5, fig. 8, represents an example of spermatozoa in pairs. Their presence in close proximity to each other is taken as an indication that the two spermatid nuclei that differentiate from the nucleus of an auxocyte may transform into two functional spermatozoa. In this figure, one of the pair is seen from the basal-side view; only the basal portion of the other is shown. Both spermatozoa show the central position of the nucleus in the nuclear cup.

Histogenesis in this group differs in many aspects from both of the two modes of spermiogenesis that we observe in *S. tranquebarica.* In the initial phases: (1) no tetrad formation is seen; (2) no pairing of chromosomes; (3) only a limited portion of the cytosome is actively involved. These are in sharp contrast to the mode of spermiogenesis involving the class of auxocytes (with tetrad formation) in *S. tranquebarica,* wherein the whole cell participates actively.

Compared with the mode of spermiogenesis that takes place in the class without tetrad formation, the contrast is also obvious. In *S. tranquebarica,* the nucleus of an auxocyte differentiates directly into a spermatid; presumably, this takes place by incorporating some of the cytoplasm after the sloughing off of a certain amount of the karyoplasm. In *S. oceanica,* on the other hand, the auxocyte nucleus splits first into two spermatid nuclei; then each nucleus reorganizes into a spermatid by incorporating a certain amount of the surrounding cytoplasm.

However, in the later phases of spermatid-transformation, the above mentioned three quite distinct modes of spermiogenesis run parallel in several aspects as indicated by: (1) the series of concentration, contraction and sloughing off of some materials with the consequent diminution of the size of the spermatid, each time followed by differentiation and reorganization until the definitive spermatozoön form is attained; (2) the behavior and movements of the acroblast and acrosome are essentially similar.

The chromosomes (Plate 5, fig. 9) of *S. oceanica,* exhibit the tendency of being formed loosely by groups of twos, threes (triosome or triplicate), and fours (quadruplicate) sets of chromatids. This is in contrast with the distinct-segmented character of the chromosomes of *S. tranquebarica.* (Plate 3, figs. 4, 5 and 7.)

The haploid number of chromosomes in *S. oceanica* is six (Plate 5, fig. 10). There is only one mode of spermiogenesis, in contrast to the two methods of sperm formation in *S. tranquebarica.*

SPERMIOGENESIS IN S. SERRATA VAR. PARAMAMOSAIN

Histogenesis in this group closely parallels that of *S. tranquebarica* in the sense that there are two types: (1) in one mode of spermiogenesis, the whole cell is practically involved actively. This is indicated in Plate 5, fig. 11, which shows a pro-spermatid in the contraction phase with some of its cytoplasmic and chromatin materials being sloughed off. The size is relatively large compared with that of the kinoplasmic area indicated in Plate 6, fig. 1.

We need not follow closely the details of the changes. On the whole, it can be said that, the phases of transformation broadly resemble in many essential details the spermiogenesis in one class of auxocytes (with tetrad formation) in *S. tranquebarica.*

(2) The other type involves some broad aspects which suggest a mode of spermatid-differentiation somewhat intermediate between that in *S. oceanica,* on one side, and that in *S. tranquebarica* (only in auxocytes without tetrads), on the other, that is, if we are to base the condition on the kinoplasmic area. There seems to be a degree of gradation regarding the relative amount of the cytoplasm which is actively involved—practically nil in *S. tranquebarica* (only in auxocytes without tetrads), small in *paramamosain,* and considerably greater in *S. oceanica.* (Cf. Plate 4, fig. 5; Plate 6, fig. 1 and Plate 5, fig. 3.)

In *paramamosain,* the nucleus with some portion of the cytosome (Plate 6, fig. 1) differentiates from the auxocyte and splits into two, each half transforming into a spermatid. The mode of spermatid-differentiation in this group is different then from what were observed in the two other groups (*S. tranquebarica* and *S. oceanica*).

Frequently, two spermatozoa can be seen side by side within the remains of an auxocyte. This indicates that the two spermatozoa must have developed from two spermatids, like the two referred to above. Plate 6, fig. 2, represents one of such pairs; the two spermatids have already attained the definitive form of the sperm; apparently, they have to undergo reorganization before they become full-fledged spermatozoa. The reticular appearance of the auxocyte body is noteworthy; the same condition may be observed in Plate 4, fig. 5. Perhaps, this condition is due to the withdrawal of the cytosome from some parts of the cell during the time when the spermatids are differentiating from the auxocyte body. Presumably, the large clear space (Plate 6, fig. 2, *c*) above the spermatids represents the centrosome with some centrioles and centroplasm.

It is not unlikely to find two types of spermatozoa in the variety *paramamosain,* since there are two modes of spermiogenesis. This condition is observed in *S. tranquebarica.*

SPERMIOGENESIS IN S. SERRATA (FORSKÅL)

Spermiogenesis in this group proceeds in two distinct fashions varying distinctly in some details from the types that are observed in the preceding groups. In this species, the spermatids may differentiate from the auxocytes by either of two quite distinctly different methods.

I. In one class, after the growth period, the auxocyte nucleus undergoes a somewhat general reorganization. This involves both karyoplasmic and chromatin materials and their subsequent diminution (Plate 6, figs. 7, 8 and 9). The spermatid so differentiated then undergoes transformation.

Plate 6, fig. 7, shows an auxocyte nucleus apparently in the phase of the series of changes that lead to its transformation into a spermatid body. The chromosome-nucleolus appears as a condensed mass, while the other chromosomes are visibly still somewhat in a reticulated condition. The karyoplasmic materials are more or less concentrated on the opposite pole. The centrosome (*c*) appears as a clear space containing some centroplasm. With acid fuchsin, anilin blue and haematoxylin, the latter appears as a somewhat dark mass with a bluish tint.

In the subsequent contraction phase, some of the materials are sloughed off. Plate 6, fig. 8, shows a picture wherein the process is apparently going on. The karyoplasm is in the diffused condition and the chromatids, excepting those that constitute the sex-chromosomes, are aligned along the periphery of the differentiating body.

Plate 6, fig. 9, shows a phase of reorganization following the differentiation and the subsequent sloughing off of some materials. The spermatid nucleus is in the netlike stage or resting period and the chromosomes are temporarily in a reticulated condition. The sloughed-off materials (*rp*) are seen above it.

Spermatids differentiated in this manner seem to be less common than the other class and, in their later phases of transformation, have not been followed very closely. This is quite difficult, because the determination as to how a spermatid differentiates from the auxocyte is rather uncertain. It is quite true that the spematids belonging to the other class usually occur in pairs and, hence, they can be reorganized easily; but there still remains the uncertainty due to the accidental separation of the pairs which may happen during the sectioning of the tissues.

II. The other form of spermiogenesis in this species is characterized by the differentiation of the auxocyte nucleus as a body to form the spermatid nucleus (Plate 6, fig. 10). This then proceeds to reorganize and ultimately splits into two. Perhaps this explains the fact that many spermatids and spermatozoa are in pairs. Plate 7, fig. 4, shows a pair of spermatids still within the auxocyte body. The photomicrographic picture of a spermatocyst (Plate 6, fig. 6) also illustrates this condition.

The process of division is featured by what we may term "progressive heteropycnocis." The chromosome-nucleolus appears to be the focal point around which the activities are more obvious. The following figures illustrate some of the more characteristic features.

Plate 6, fig. 10, shows the nucleus of the auxocyte at the termination of the growth period. Apparently the resting phase, which is indicated by the netlike stage, or resting condition, in which all the other chromatin materials are reticulated; they are being broken by the initiation of activities. This can be inferred from the apparent tendency of the nuclear material to concentrate around the chromosome-nucleolus.

Obviously this results in the realignment of the nuclear constituents which finally segregate into two portions (Plate 6, figs. 11, 12, and Plate 7, fig. 1).

Plate 7, fig. 2, shows the nucleus only, wherein the chromosome-nucleolus (presumably the XX-chromosomes) now elongates at the equatorial region. The doubled appearance and the presence of clefts at both ends, instead of the two ends tapering and pointed, as observed by some authors in other animals, indicate that, in this particular case, the chromosome-nucleolus is composed of the XX-chromosomes. Obviously the pair is in diakinetic position, preparatory to their separation; hence, each daugther nucleus will have one X-chromosome.

The process of division is shown in Plate 7, fig. 3. A peculiar feature is seen in the sudden appearance of presumably the idiosome (*i*) at the angle where the splitting takes place.

Basing on what has been observed regarding the rôle and the active participation of the idiosome in the process of transformation in the other groups, it can be inferred that in this case a portion of the idiosome is incorporated into the body of each spermatid during the reorganization that follows the division.

This view is apparently supported by the appearance of the acroblast in a later phase (Plate 7, fig. 5). The acroblast appears at the apex of a cuplike structure; the nucleus fills the mouth of the cup. In this connection, it may be pointed out that the features and the circumstances associated with the apperance of the idiosome and the acroblast are different from what have been observed in *S. tranquebarica.*

The features are also different in the two other groups (*S. oceanica* and in the variety *paramamosain*), where the acroblast appears suddenly within the idiosome in the apical pole of the spermatid; whereas in this species (*S. serrata*), the idiosome appears first in the cytoplasm of the auxocyte at the place where the nucleus is splitting. On the whole, however, in the last three groups, namely: *S. oceanica,* the variety *paramamosain,* and *S. serrata,* the appearance of the acroblast takes place at some later stage of the transformation.

Plate 7, figs. 6 and 7, represent spermatids in the later stages. Plate 7, fig. 8, shows a spermatozoön. The existence of two classes of spermatozoa in this species is a possibility that can be inferred from the two distinctive ways by which spermatids differentiate from the auxocyte.

GENERAL SUMMARY AND COMPARISON

The principal points brought out in this study of spermatogenesis in these four groups of crabs are the following:

1. The lumen of the follicular tubule is lined by a single layer of cells. These cells are of three kinds: (*a*) the spermatoblasts; (*b*) the nurse cells; (*c*) the secretory cells.

2. The spermatoblasts (auxocytes) grow at the expense of the nurse cells and eventually develop into spermatozoa. The cells of the gonads of these four groups show discernible differences in size, form, and in their structural make-up. Generally, the spermatoblasts develop singly, but in some cases several cells may form into a group enclosed by a cyst. This group formation is called spermatocyst. Spermatocyst formation occurs quite commonly in *S. serrata* and its variety *paramamosain*, but quite rare in *S. tranquebarica*. It does not seem to occur in *S. oceanica* (*banhawin*).

3. The ways by which spermatids differentiate from the auxocyte differ in some broad aspects:

a. In *S. tranquebarica*, it proceeds in two ways:
   (1) First, there is a pro-spermatid stage, which is characterized by the sloughing off of considerable amount of both cytoplasmic and karyoplasmic materials, leading to the formation of the definitive spermatid body. There is tetrad formation. The haploid number of chromosomes is six.
   (2) Second, the nucleus, perhaps with a certain amount of cytoplasm immediately around it, differentiates into a spermatid. There is no tetrad formation and the haploid number of chromosomes is five. Therefore, the sperms of *S. tranquebarica* exhibit digamety.

b. In *S. oceanica*, spermatid formation proceeds in only one way. The auxocyte nucleus first splits into two spermatid nuclei; then each daughter nucleus reorganizes by incorporating some of the cytoplasm to form into a definitive spermatid body.

c. In the variety *paramamosain*, spermatid formation proceeds in a somewhat parallel manner to that in *S. tranquebarica*, in the sense that there are also two methods, namely:
   (1) In one type, as in *S. tranquebarica*, there is a pro-spermatid stage; that is, the formation of the definitive body is preceded by gradual diminution of both the cytoplasm and nuclear materials.
   (2) In the other type, the auxocyte nucleus differentiates as a body from the auxocyte by forming an active kinoplasmic area in which only a very limited amount

of the cytoplasm is incorporated. This active mass soon splits into two, forming two spermatids.

d. In *S. serrata*, spermatids may differentiate from the auxocytes by two methods: one resembles somewhat the mode of spermatid differentiation (only auxocytes without tetrad formation) in *S. tranquebarica*, but rather more abbreviated; this is rather obscure and needs to be studied further. The other method parallels that of *S. oceanica*, but in a fashion that is somewhat abridged and involves only considerably less cytoplasm.

(1) In the first case, the auxocyte nucleus is transformed into a spermatid through a process of differentiation and reorganization during which some of the materials are sloughed off. Apparently, if at all, only one spermatozoön develops from the auxocyte.

(2) In the second, the nuclear materials undergo a sort of realignment distinctly different in features from those observed in the first. The nucleus then divides into two spermatid nuclei, and each daughter nucleus reorganizes to form into a spermatid. Evidently, two spermatozoa are produced. Progressive heteropycnosis is a very conspicuous feature in this type of spermatid formation.

4. In all groups the main features of the transformation of spermatids to spermatozoa involve a series of processes of concentration, contraction, and diminution of both of the cytoplasmic and nuclear materials including other cellular bodies.

5. One main interesting feature involves the participation of the idiosome, the appearance and movement of the acroblast body tending toward the subsequent formation of the capsule.

6. The general form of the sperms is conical; the broad basal portion that holds the nucleus is the nuclear cup, the rim of the cup and the conical portion constitute the capsule. This latter is apparently composed of the idiosome which holds the non-chromophyllic "sphere-substance", and the acroblast material. The differences in size and in general outline between the spermatozoa of these four groups of crabs, and even between the spermatozoa of the same variety, are quite discernible. These differences, however, are hard to determine accurately due to several causes, such as: (1) the difficulty of getting accurate observation because of their being very minute; (2) the variable factors involved in staining and destaining, etc.

THE FEMALE ORGANS

The abdomen is broad and all the segments are freely movable, (Plate 1, fig. 4). There is a pair of appendages on each of

the second, third, fourth and fifth somites. The external genital apertures (Plate I. fig. 1, *g. o*) are a pair of large openings situated on the sternum of the sixth thoracic somite. The sterna are not so concave as those of the male, and the abdomen is not so closely applied to the thorax.

The ovaries (Plate 1, fig. 2) are paired, and lie in a position similar to that of the male reproductive organs. There is, however, a considerable posterior prolongation of each ovary. As in the male, the two anterior lateral portions are connected behind the pyloric foregut, the connection forming a sort of a bridge over the midgut. Behind this transverse connection, each ovary is prolonged backwards as a narrow strip extending to the extreme posterior end of the thorax, where they fuse together in mature specimens. These posterior extensions of the ovaries occupy a similar position to that of the vasa deferentia of the male; that is, they lie above the hindgut and below the pericardium. Beneath the anterior portion of the latter, each posterior branch is connected on its outer side with a large sac, the spermatheca (*spt*). This continues as a short oviduct which opens to the exterior by means of the vulva on the sternum of the sixth thoracic somite.

The seminal receptacle is composed of two parts, namely: (1) the glandular portion which is contiguous with the ovary, (2) the portion lined with chitin which is continuous with the oviduct. The oviduct (Plate 1, fig. 2, *od*) is chitinous, its terminal portion expanded to form a sort of funnel-like structure leading to the vulva.

The condition of the ovary depends upon the degree of maturity of the ova. When immature, the gonads are small and pale, and the presence of the eggs cannot be detected by the naked eye. But when mature, the gonads fill up almost the whole dorsal surface of the cephalothorax. They are orange-red and the eggs can be readily distinguished. The red color is due to the presence of a large amount of yolk.

The ovary is composed of numerous follicular tubules. When immature, the general outline in cross-section (Plate 1, fig. 3) is that of a triangle, with the apex fitting into the sterno-carapace angle. With the ripening of the eggs, the ovarian walls become very much distended; the outline of the gonads at this time becomes irregular. The gonads fill up the sterno-carapace angle and practically covering up the entire dorsal surface of the branchial region beneath the hypodermis. The follicles are no longer distinct; under the microscope, only some portions

of the follicular walls can be seen. The epithelial cells are obliterated; the gonads being filled up with compact masses of eggs.

The cavity of the follicular tubules (Plate 7, fig. 9) is lined by a single layer of epithelial cells. These cells may be grouped under four categories, namely: (1) ooblast; (2) nurse cells; (3) the secretory cells and (4) the auxiliary secretory cells.

The secretory cells.—Compared with those present in the testicular follicles, the ovarian secretory cells are generally bigger and more numerous. In a young ovarian follicle, there seems to be no marked differences between the principal and the auxiliary secretory cells, as both groups are vacuolated, the only difference being in the presence of a large vesicle in the former. This vesicle begins to enlarge (Plate 7, fig. 9, *c. c*), the enlargement seemingly correlated with the dissolution of the materials of the adjacent cells. In other words, the adjoining vacuolated cells act as auxiliary secreting cells by yielding their materials for the production of the metaplasm of the principal secretory cells. Presumably, there must be an enzyme the action of which is responsible for the conversion of cellular materials into secretory products. This metaplasmic product takes up a bluish color with iron-hæmatoxylin, acid-fuchsin and anilin stain combination.

OÖGENESIS

The oöblast (auxocytes) develop into eggs; that is, the epithelial cells metamorphose directly into ovocytes without division. The auxocytes can be easily recognized from the nurse cells by their relatively bigger germinal vesicles, and the presence of more cytoplasmic materials. In a young auxocyte, the cytoplasm is at first small in amount and simple in structure, seemingly consisting almost wholly of optically homogeneous hyaloplasm. As growth proceeds, the appearance becomes more or less alveolar, and there is an enormous increase in the amount of oöplasmic substance. In well-stained sections, streamers of both karyoplasmic materials and cytosome from the neighboring cells are discernible. The growing auxocyte does not only receive material contributions from the neighboring cells, but in some cases it engulfs a whole cell. Vestiges of such engulfed cells are quite apparent in some full-grown auxocytes.

The description above is based on the auxocytes of *S. oceanica* and those of *S. tranquebarica.* The auxocytes of the variety

paramamosain and especially those of *S. serrata* appear to be smaller and less alveolar; hence, they appear more compact.

The process of oögenesis parallels that of spermatogenesis to a certain extent. Both processes are featured by the growth of the auxocytes at the expense of the nurse cells; likewise, both germ cells undergo transformation at the termination of their growth period.

Oökinesis.—The amitotic oökinesis through which the ovocytes pass is apparently less complicated, compared with the changes that feature spermiogenesis. And, like the latter, the phases of transformation in each of the four groups differ in many aspects, some features being distinctive within the group.

OÖKINESIS IN S. TRANQUEBARICA

This proceeds in somewhat similar fashion as spermiogenesis with respect to the extent of the kinoplasmic area involved, namely: (1) in one type, the whole cell is actively involved; (2) in the other, only the nucleus and the area immediately around it participate actively. These two modes of oökinesis produce ovocytes that show differences in size, and also in the constitution of their chromosomes. The latter aspect, however, seems to be temporary in nature. These two forms of ovocyte are referred to as the macro and the micro-type.

The following figures illustrate some of the characteristics that feature the development of the macro-ovocytes.

Plate 7, fig. 10, shows the surface view of two developing auxocytes and Plate 7, fig. 11, represents one from the cross-section of a follicular tubule. The disorganized state of both the cytosome and the nuclei of the nurse cells is an indication that some of their materials are being absorbed by the growing auxocytes.

Plate 8, fig. 1, represents an ovocyte at the termination of the growth period. The germinal vesicle has grown to almost four times its original size. It seems to be in the zygotene stage. The pairing of the spireme is quite obvious. Around the germinal vesicle, roughly in the form of a horse-shoe, is the pallial layer, or vitellogenous mass (*v;* also Plate 12, fig. 4). The Golgi-bodies are seen as the heavily stained masses scattered in this layer. Vestiges of a nurse cell are discernible.

In Plate 8, fig. 2, the size of the ovocyte and its germinal vesicle has decreased considerably. Perhaps this is because of the contraction and the subsequent sloughing off of some of the cellular materials. The condition of the germinal vesicle is apparently that of the pachytene stage, some pairs of spireme

having fused and became thicker threads. The tetrad formation is evident in both Plate 8, figs. 1 and 2, as shown by the alignment of chromatids into groups of four. The vitellogenous layer is no longer present, but instead, irregular spherule masses that stain quite deeply at the periphery are scattered in the cytoplasm. Presumably, these masses foreshadow the formation of yolk-masses that develop later. Apparently these masses became finely disseminated through the oöplasm, since they do not appear in the stages immediately following.

Plate 8, fig. 3, shows the chromosomes scattered in the homogeneously diffused karyoplasm. There are apparently twelve, excluding the supernumerary ones. The masses containing deeply stained bodies are presumably composed of extruded nuclear materials and some Golgi-bodies. The XX-pair (*h*) is conspicuous. Apparently the germinal vesicle is undergoing an unequal division, leading to the formation of the first polar body; and the extrusion of some nuclear material takes place simultaneously.

Plate 8, fig. 4, shows an ovocyte with the polar nucleus being extruded out, together with some cytoplasmic material. It is in the contraction phase.

It seems that the ovocyte after the extrusion of the first polar body either goes through a temporary resting stage (Plate 8, fig. 5) or proceeds in its development. The latter case is indicated in Plate 8, fig. 6. The formation of chromatids in groups of twos indicates the dyad formation and their alignment with respect to the other pairs implies that they are in parasynaptic association. The six chromatids in a circle compose the hetero-chromosomes (*h*), the XX-pair in this case, since they are more or less alike. The monosome (*m*) is shown as a heavily stained body close to the nuclear wall.

Plate 8, fig. 7, shows the chromosomes prior to the second meiosis. The hetero-chromosomes (*h*) are easily recognizable, as is the monosome (*m*) which has no pair. Presumably the clear area in the vicinity of the germinal vesicle is the attraction sphere (*a. s*) and the two slightly stained masses within are the division centers (centrioles).

It can be inferred from Plate 8, figs. 7 and 8, that the formation of the second polar body apparently proceeds in this manner: (1) the division centers move apart, followed by the constriction of the attraction sphere; (2) the nuclear materials then become disseminated around the two division centers and

(3) around each division center a nucleus is reformed. One will become the second polar body.

In Plate 8, fig. 9, the two daughter nuclei have separated; evidently the smaller is the second polar body (*p. b* 2). In the subsequent contraction, these two bodies are pulled apart (Plate 8, fig. 10). The second polar body is distinctly recognizable by the presence of several chromatids that are irregularly disposed. The egg nucleus is bigger, with the chromosomes aligned along the nuclear wall. The expulsion of the polar nucleus will probably take place at the termination of the contraction phase.

The division that has taken place cannot be considered as an equational, but reducing division, since qualitatively dissimilar halves are produced. The first polar division may also be so characterized. Hence, the maturation division in this crab is an exception in the sense that ordinarily one maturation division is supposed to be equational and the other reductional.

Oökinesis in the micro-type.—The mode of oökinesis that leads to the formation of the micro-ovocytes is seemingly less involved, but the changes are rather obscure. The activity appears to be localized in the germinal vesicle, involving only that portion of the cytosome immediately around this body. In other words, the kinoplasmic area includes only these portions of the auxocyte.

From Plate 9, figs. 1 and 2, we can infer that at the termination of the growth period, the germinal vesicle with some portion of the cytosome differentiates as a body from the auxocyte to form the ovocyte. In this mode of oökinesis, there is seemingly an attempt at shortening the process of transformation.

Plate 9, fig. 1, shows an ovocyte that has differentiated from the auxocyte, with the first polar body (*p. b* 1) already formed. The deeply stained bodies scattered in the cytosome are probably Golgi-bodies.

In Plate 9, fig. 2, the polar nucleus is already extruded. Evidently the number of chromosomes is six, but they are bivalent. The heterochromosome (*h*) is easily recognizable, being the biggest and broadly V–shaped.

The second polar body.—The formation of the second polar body in the micro-ovocytes takes place after the completion of the growth period and after the sperm has penetrated into the germinal vesicle of the ovum. This fact is borne out by the presence in the ovary of full-grown crabs of germinal vesicles which are about twice as big as the germinal vesicles of the other groups. Plate 10, figs. 1 and 2, show the relative sizes of the

germinal vesicles of the two classes of ova, the macro-ovum and the micro-ovum, respectively. The dyad formation is still recognizable in Plate 10, fig. 2. Another evidence is seen in the presence of polar bodies still attached to the eggs that are already glued to the endopodite setæ (Plate 13, fig. 2). Since the eggs are already in advanced stages of development, it is quite apparent that the formation of these polocytes must have taken place in already mature eggs, or perhaps even later when these eggs are already outside the body and undergoing cleavage.

Quite frequently some protozoa, especially stalked ciliates, attached themselves to the eggs. Their reaction to the fixatives is to contract and round up; hence, they are likely to be confused with the polar bodies. They can be distinguished easily, however, by their elongated and deeply stained nuclei; while the polar bodies have clear nonstaining rounded vesicles, and in most cases, the protoplasmic connection between a polocyte and an ovum is still visible.

THE MATURE OVUM

From the time of the formation of the polar nucleus the egg increases immensely in size, from about 29 microns to over 266 microns in diameter. Undoubtedly this great increase in bulk represents a considerably long period of growth. Plate 8, fig. 10, and Plate 9, fig. 3, give a comparative idea regarding the increase in bulk of the ovum.

The appearance becomes alveolar because of the presence of closely crowded yolk-spheres suspended in the hyaloplasm, in which also lie numerous smaller granules of various kinds, some fatty materials and pigment granules. The ovary then becomes more compact and assumes a bright orange-red color and there are no longer recognizable traces of either the secretory or the nurse cells. These cells which originally constitute the main bulk of the follicle must have been used up to furnish materials for the growth of the ova.

The position of the germinal vesicle is invariably near the center, in the young ova and also in older ones which happen to be free from pressure. In closely crowded ova, the germinal vesicles become eccentric in position. The wall of the germinal vesicle is generally distinct in most places, except at points where it merges with the cytoplasm and from which radiating protoplasmic streamers branch outward to the peripheral cytoplasmic layer (blastema) around the egg. These

protoplasmic strands course deviously through the spaces between the yolk-spheres, and they form the connecting links between the germinal vesicle and the rest of the egg. The eggs are distinctly centrolecithal.

The foregoing description is based upon the eggs of *S. tranquebarica.*

OÖKINESIS IN S. OCEANICA

There is only one mode of oökinesis in this species. It proceeds in a manner somewhat similar to the mode of oökinesis that produces the micro-ovocytes in *S. tranquebarica.* There are distinct differences, however, as follows: (1) the bulk of the auxocyte; the first polar body (*p. b*^{1}) is already expelled. atively much greater in the auxocytes of *S. oceanica;* (2) hence, the ovocytes that develop are relatively bigger (Plate 9, fig. 2, and Plate 10, fig. 8); and (3) the formation of the second polar body follows immediately that of the first polocyte. In contrast with *S. tranquebarica* which exhibits sexual dimegaly, *S. oceanica* produces only one class of eggs.

Plate 10, fig. 7, shows an ovocyte that has differentiated from the auxocyte; the first polar body (*p. b*^{1}) is already expelled. The chromosomes are apparently getting into the diffused condition. Within the germinal vesicle are two "intra-nuclear division centers" (*i. dc*), one of them apparently moving toward the periphery. Presumably this foreshadows the formation of the second polar body. A feature of the process is shown in the other ovocyte, where the attraction sphere or portion of it is now seen outside the germinal vesicle. Apparently the second meiosis, or formation of the second polar body, takes place by the flowing out of some nuclear materials into that portion of the attraction sphere outside the germinal vesicle. Evidence that such actually happens is the presence of two division centers in an older ovum (Plate 10, fig. 8, *i. dc., e. dc*) —one intra-nuclear, while the other is extra-nuclear. It seems that in this case the materials which had been withdrawn from the germinal vesicle supposedly to compose the materials of the second polar body were not cast off, but are disseminated within the ovum. Obviously, both maturation divisions in this group are reductional, as in *S. tranquebarica.*

Plate 10 fig. 8, and Plate 11, fig. 1, show the young ova in different phases of growth. In the first, the nuclear framework, that is, the nuclear wall and the network, are still well defined. In the other figure, the network has disappeared;

the germinal vesicle has increased considerably in size and so has the bulk of the cytosome. A spermatozoön (*sp.*) has penetrated into the cytoplasm.

Plate 11, fig. 2, is a photomicrograph of a large portion of a mature ovum. The yolk-spherule masses of various sizes appear as black. Within the germinal vesicle, the sperm can be seen as a black mass. A line is drawn to mark the boundary of the ovum and that of the adjoining one.

OÖKINESIS IN PARAMAMOSAIN

In this group, two classes of ovocytes are produced. As in *S. tranquebarica,* they are designated as the macro- and micro-ovocytes. In *S. tranquebarica,* however, the features of the changes that lead to the differentiation of these two classes of ovocytes from their respective auxocytes differ markedly.

In the *paramamosain* the general nature of the changes is somewhat closely identical. The two classes of ovocytes differentiate from their respective auxocytes in about the same manner; in both, some kind of reorganization takes place in the nucleus, resulting in the sloughing off of some of the nuclear materials. Then, the remaining nuclear portion, together with a certain amount of cytosome, reorganizes to form the ovocyte. There are, however, features, that distinguish the two classes of ovocytes: (1) the marked difierence in size between the respective auxocytes including their nuclei; (2) the amount of cytosome involved, and the consequent difference in size of the ovocytes that develop, Plate 11, fig. 5, and Plate 12, fig. 3; (3) in the micro-ovocytes, the sloughed off materials form a mass, presumably forming the polar nucleus, Plate 12, fig. 3, *p.n.* This condition does not seem to be the case in the macro-ovocytes, wherein the sloughed off materials, apparently disseminate in the cytoplasm and presumably contribute to the materials of the ovocyte. Some of the characteristic features are shown in the following illustrations.

Plate 11, fig. 3, shows a full-grown auxocyte (macro-class), apparently in the contraction figure or synisezis. In this case, the leptotene-threads do not seem to show any tendency towards definite polarization, while the chromatids appear to shift. A conspicuosuly large centrosome (*c*) with some centroplasm lies above the nucleus.

Presumably the above condition is followed by the diffused stage, Plate 11, fig. 4. This is characterized by more or less diminished basophily and a loosening of the threads, which have

become more or less deconcentrated. It seems significant that the prochromosome threads are still distinguishable and that they are distinctly double, the halves or the pairs being widely separated. The tendency towards polarization is shown in the nucleus, which is divisible into two zones, namely: (1) the portion adjoining the centrosome wherein the materials are completely diffused and (2) the other portion holding the pro-chromosomal threads which run towards the opposite pole. Obviously the materials within the completely diffused area are being disseminated into the cytoplasm. In other words, the nuclear elements are undergoing reorganization preparatory to the differentiation of the ovocyte.

Plate 11, fig. 5, shows the second synizesis or contraction-figure. The nuclear substances are again concentrated in some degree. A similar change is also taking place in the cytoplasm. Apparently, the chromatids are being set in their alignment. One significant feature is the diminished size of the centrosome, compared with that in the preceding stages. The definitive form of the ovocyte is presumably attained at the completion of this phase.

The differentiation of the micro-ovocyte proceeds in a somewhat similar fashion. Plate 12, fig. 1, shows a micro-auxocyte in the contraction figure, or synizesis. The nucleus shows distinct polarization, the materials in the region adjoining the centrosome are more diffused; these materials are apparently drawn to this zone, the threads which are rather rough in outline are directed towards the centrosome. In the opposite pole, however, the threads are thinner and the chromatids are apparently being shifted. The nuclear figure may be regarded as similar to the so-called "amphitene" phase of some authors if polarization and the formation of two types of threads are taken as the sole bases. The case seems to be different, however, in the sense that the formation of the thicker threads is due to the crowding of nuclear materials preparatory to their being slouged off.

Further contraction results in another contraction-figure, or synizesis, Plate 12, fig. 2. On the side adjoining the centrosome, a portion is pinched off from the main nuclear body. The shifting of the centrosome towards the apical region of the differentiating ovocyte seems to be associated with the somewhat abortive nuclear division. Apparently the segregation of nuclear materials is taking place; the pro-chromosomal

threads are shown radiating from the condensed, deeply stained mass located at the place of division.

In Plate 12, fig. 3, the micro-ovocyte is shown to have completely differentiated from the auxocyte body and the two nuclear portions have also separated, the smaller one (*p. n.*) presumably representing the first polar nucleus. It appears to be within the centrosome. Wether the micro-ovocytes develop into functional ova is yet to be determined. There are indications to the contrary.

A photomicrograph (Plate 12, fig. 4) of a portion of the ovary shows that some of the developing ova appear to be stunted (*mi*); presumably these are some of the micro-ovocytes. Some sperms (*sp*) may be seen outside the eggs; one (sp_2) is shown as having penetrated into the cytoplasm of a growing ovum and another (sp_1) may be seen already inside the germinal vesicle. The heavy black ring that partially surrounds the germinal vesicle represents the vitellogenous layer, or pallial substance. It is apparent that in these crabs insemination may take place even before the ova become full-grown.

OÖKINESIS IN S. SERRATA

The following illustrations are taken from the sections of the ovary of a young female, which measures 7.7 cm. across the carapace. The color of the ovary is orange, and from all appearances, it looks normal like the ovaries in mature females. The cells appear to be developing normally. It is rather doubtful, however, whether the eggs can be fertilized in this stage; there are apparent obstructions in the form of the deep sternal concavity which partly hides the rather too small opening of the vulva.

In this species, the process of oökinesis proceeds in a manner not very much different from that in *S. oceanica*. In both species, the differentiation of the ovocyte takes place simultaneously with the diminution of the nuclear materials and the formation of the first polar body.

Plate 12, fig. 5, shows an auxocyte after the growth period. It presents a contraction-figure, or synizesis. Some of the threads radiate from the condensed heavy mass at the center, while those that are close to the border form loops.

In Plate 12, fig. 6, the ovocyte has differentiated from the auxocyte body; the polar nucleus (*p. n.*) and some nuclear materials have been extruded. The quadripartite constitution of the chromosome-nucleolus, which is presumably the X-chro-

mosome, is distinctly shown. The prochromosomal threads are apparently undergoing realignment.

Plate 12, fig. 7, shows an ovocyte where concentration and contraction processes are apparently going on. The first polar body (*p. n*) is still embedded in the cytoplasm. The centrosome (*c*) with some centroplasm is distinctly visible.

Plate 12, fig. 8, shows a contraction phase and the sloughing off of some cytoplasmic materials. The two polar bodies are still within the ovum.

The form, size and character of the chromosomes are shown in Plate 12, figs. 9 and 10; the X-chromosome, or chromosome-nucleolus, is quadripartite.

SUMMARY AND COMPARISON

The principal points in oögenesis may be summarized as follows:

1. The auxocytes (oöblasts), after a period of growth characterized by a greatly increased bulk at the expense of the nurse cells, metamorphose directly into ovocytes.

2. At the termination of the growth period, the auxocytes undergo transformation. The process is characterized by features that are quite distinctive for each group.

3. In *S. tranquebarica,* oökinesis proceeds in two distinct ways: In one type, the differentiation of the ovocyte from the auxocyte involves practically the whole cell. In the other the kinoplasmic area includes only the germinal vesicle and a very limited portion of the cytoplasm around it. In other words, the rest of the cell does not participate actively. Consequently, two classes of ovocytes are formed, namely: the macro-ovocytes and the micro-ovocytes. The macro-ovocytes complete the maturation period earlier; the formation of the second polar body follows immediately that of the first polocyte, The oötid then proceeds to grow into mature ovum. In the micro-ovocyte the formation of the second polar body takes place when the ovocyte has become full-grown ovum, and after insemination has taken place. There is no corresponding oötid formation, and it seems that the penetration of the sperm into the germinal vesicle is necessary before the formation of the second polar body can take place. Throughout the period of growth to the time of the formation of the second polar body, the number of chromosomes is six, but they are bivalent. The chromosomes become univalent after the formation of the second polar body. Apparently, the eggs of *S. tranquebarica* exhibit sexual dimegaly.

4. In *S. oceanica* (*banhawin*) the formation of the first and second polar bodies seems to run parallel with the differentiation of the oötid from the auxocyte. Only one class of eggs is produced.

5. The *paramamosain* variety has more in common with *S. tranquebarica* in the sense that both groups produce two classes of ovocytes. One main difference between them lies in the fact that the micro-ovocytes in *paramamosain* do not appear to develop into normal eggs, in *S. tranquebarica* the two classes of ovocytes develop into functional ova.

6. The process of oökinesis in *S. serrata* has much in common with that in *S. oceanica;* in both the differentiation of the ovocyte from the auxocyte takes place in conjunction with the formation of the polar bodies. Both produce only one class of eggs; that is, they do not exhibit sexual dimegaly.

FERTILIZATION

During copulation the spermatophores are transferred from the vas deferens into the vulva of the female and into the spermatheca where they are stored. By some means the spermatophores find their way into the lumen of the ovarian tubules, where the spermatozoa are released from the enclosing capsules.

If a crushed portion of a fresh testis is examined under the microscope, the material has the appearance of an alveolar substance containing numerous globules of various sizes. The bigger ones, which vary considerably in size, are probably fat globules. The spermatozoa appear as very minute globular bodies resembling cocci bacteria, except that they show some sort of oscillatory movement. The tapering conical portion of the sperm body is not visible except in stained sections.

The relation of the spermatozoa to the eggs taken from the lumen of the ovary of a *parabanhawin* (*S. tranquebarica*) is shown in Plate 8, fig. 11; Plate 9, fig. 3; Plate 10, figs. 1 and 3, also in Plate 12, fig. 4, which is a photomicrograph of a portion of the ovary of a *paramamosain.*

I cannot state definitely how the entrance of the sperm into the ova is effected in these crabs. Investigators on other crabs differ in their observations. Koltzoff (1906)[12] claimed that in certain decapods, the spermatozoa settle on the eggs with the clear cup towards the egg and the capsule pointed away from the egg. He believed that the rebound from the explosion of the capsule is sufficient to drive the nucleus into the egg.

Binford (1913)[2] observed that in *Menippe mercenaria* the entrance of the sperm into the egg is effected by the turning

inside out of the tubule and capsule. According to him, the nucleus does not even enter the egg; hence, it does not participate in the process of fertilization. The fact that the nucleus holds the chromosomes regarded to be the bearer of paternal qualities to the egg, and hence, are the essential thing in fertilization, he tried to reconcile by assuming that during the transformation of the spermatid, the nuclear material, at least the chromatin, is transferred to the capsule. He said: "the contents of the capsule may be derived from the nucleus of the spermatid and is probably oxychromatin which deposits basichromatin after it enters the egg and so gives rise to the chromosomes of the male pronucleus".

In the present crabs the whole sperm enters the egg, and both nuclear cup and capsule play important rôle. But the mode of penetration and the dynamics involved are problems that need further study. It seems that some kind of an eversion which is explosive in nature takes place, whence the nuclear cup is turned inside out. This is suggested in Plate 8, fig. 11, and Plate 10, fig. 3.

Insemination.—This process may take place as early as during the early part of the growth period of the ovum (Plate 8, fig. 11, and Plate 11, fig. 1) or later, when the egg has attained its full growth (Plate 9, fig. 3). The eggs are relatively so large and opaque and the spermatozoa so very minute that it is impossible to observe the actual process. Inference can merely be made only from a study of a series of sections of the fertilized eggs.

By some means a sperm finds its way into the germinal vesicle, where the penetration path is discernible, but the path through the yolk-laden cytoplasm is entirely obscured. There is no actual bodily fusion between the male and the female pronuclei; that is, they do not unite to form a single nucleus, or conjugation nucleus.

CHANGES IN THE GERMINAL VESICLE

The following description is based upon the eggs of *S. tranquebarica* (*parabanhawin*).

The enormous increase in the size of the ovum is accompanied by that of its germinal vesicle. Two classes of ovocytes previously referred to as macro- and micro-ovocyte were observed in *parabanhawin.* The germinal vesicle in the micro-ovocyte is enormously big, compared with that in the macro-ovocyte (Plate 10, figs. 1 and 3). The general framework of the germinal vesicle of the micro-ovocyte is distinctly oxyphilic; the

framework constitutes the major part and there is a decided tendency for the chromatin materials to collect at the periphery (Plate 10, fig. 2.)

After the entrance of the sperm, the germinal vesicle begins to fragment (Plate 10, figs. 3, 4); the karyoplasm becomes organized into karyomerites (*k*) and karyomicrosomes (*m*), or nuclear microsomes. The former are masses of karyoplasm containing chromosomal elements, while the latter are only granular masses or karyoplasm. These masses stream out of the germinal vesicle (Plate 10, fig. 4); hence, the germinal vesicle gradually becomes smaller and smaller and finally disappears entirely.

The tendency of the chromatin materials to align at the periphery of the germinal vesicle (Plate 10, fig. 2) assumes added significance if coupled with the apparent polarity of the formation of karyomerites (Plate 10, fig. 3, *k*). Presumably these phenomena are associated with the formation of the second polar body and may be regarded as phases leading to the segregation of the potential functional pronuclear elements from those which are to constitute the materials of the second polar nucleus. The following events seem to support this idea:

At about the time the germinal vesicle is reduced to about half its original bulk, resulting from the extrusion of the karyomerites and nuclear microsomes, the remaining part begins to differentiate into two portions. One of these portions eventually segregates and becomes the second polar body. The framework of this portion is deeply oxyphilic and appears more homogeneous than the other portion. In this latter, there are indications that the process of fragmentation is proceeding, because its wall is indistinct; the ground substance merges with the outlying materials which are largely composed of minute masses similar to those present within this body and in the karyoplasmic streamers. Eventually this portion disappears as a body, leaving in its place a homogenous granular mass. A number of masses similar to this is scattered in various parts of the egg. They are obviously cytoplasmic masses together with some nuclear materials (karyo-cytoplasmic masses.)

The formation of the second polar body in this type of eggs (micro-ova) may be summarized as follows: The potentioal formative pronuclear elements are sorted out in the germinal vesicle through the operation of agencies which are not known. The entrance of the sperm into the germinal vesicle initiates

the movement of the karyomerites and karyo-microsomes out from the germinal vesicle, and when the latter is reduced to about half of its original bulk, it splits into two portions. One of them becomes the second polar body, the extrusion of which from the egg takes place presumably during cleavage.

CHANGES IN THE YOLK

The yolk-spheres (Plate 9, fig. 3) appear at first as more or less homogenous masses, commonly bearing some pigments. The homogenous aspect of the spheres is transformed later to that of a vacuolated appearance, becoming divided into separate masses of deeply staining materials and interspersed by non-staining areas. They soon break up into smaller vacuolated bodies, which then gradually break up into small granular masses. Finally, the oöplasmic framework in the egg appears to be divided into somewhat homogenous blocks, separated by faintly staining to nonstaining lines. These lines presumably represent the protoplasmic strands that radiate from the center of the egg to the superficial cytoplasmic layer, the blastema. It is along these somewhat clear spaces that active formation of protoplasmic islands takes place during cleavage and, consequently, where the active assimilation of the yolk is going on. Along some of these areas are formed the secondary cleavage of some authors.

SPAWNING

When a crab is ready to spawn, she raises her body and assumes an upright position holding the abdomen away from the body; the abdomen together with the exopods form a sort of a basket into which the eggs are run. The eggs become attached to the setæ of the endopodites, where they pass their embryonic stages.

According to the observation of Mr. Arriola (1940), these crabs spawn throughout the year, the peak of activity falling between May and September. This observation was made at the Experimental Station of the Division of Fisheries at Dagatdagatan, Malabon, Rizal Province. My observations on the conditions of the gonads of crabs dissected during different months of the year corroborated Arriola's findings.

That the period of the peak of spawning activity may vary perhaps slightly in different regions of the Philippines is probable. For example, in Dumangas, a town in Iloilo Province noted for the abundance of *alimango,* the season of highest

spawning activity appears to be between August and November. During the intervening period, crabs with gonads full of eggs are sold abundantly in the markets.

Mr. Arriola (1940, p. 443)[10] presumed that the crabs die shortly after laying one batch of eggs. The presumption is based on the behavior of his specimens, which were kept in floating cages. I can not entirely subscribe to his view. In the first place, it should be borne in mind that the crabs are distinctly bottom-dwellers and fossorial in habit. The *mamosain*, for instance, live in burrows, while the others live concealed in mud-holes and under shelter among heaps of debris. By placing the animals in floating cages, he subjected them to unnatural conditions. Certainly, it is not safe to draw conclusions purporting to be the same with what is expected to happen under natural conditions, especially when the experiments were performed under conditions at variance with the natural setup wherein the animal thrives favorably.

In the second place, his assertion does not seem to find support from facts observed under natural conditions. According to his observations, these crabs attain sexual maturity when they reach the size of about 84 by 122.5 mm. across the carapace. Possibly, his specimen must have been a true *banhawin*, for I had in my collection a berried *parabanhawin* that measures only 100 mm. across the carapace. From the studies on the sections of ovaries and testes from crabs of different sizes, I found female crabs of 90 mm. across the carapace already with mature gonads. Nevertheless, just for the sake of having something to base on, let us take 84 by 122.5 mm. as the size at which some of these crabs attain sexual maturity. What can we say of some female crabs reaching the size of 200 mm. or 225 mm. across the carapace? Big crabs of these sizes are not very rare. Certainly, we cannot say that these crabs had not spawned previously.

Egg menbrane.—Upon reaching the exterior, each egg is surrounded by two membranes: the vitelline (or fertilization) membrane and the chorion. Between these two membranes is a perivitelline space which, according to Williamson,[11] contains a fluid possessing adhesive properties. Microscopic studies made on stained sections of both ovarian eggs and on eggs already attached to the endopodite setæ did not reveal any indication of the presence of this fluid. On the other hand, the two membranes are intimately fused in some places, though

generally the two membranes show separately (Plate 13, fig. 1 and Plate 14, fig. 1).

How the eggs of crabs become attached to the endopodite setæ is a question that has not been satisfactorily answered. Some of the earlier observers believed that a sticky substance is secreted around the eggs as they are shed. The objection to this theory is that it does not explain why the eggs become attached only to the endopodite setæ. The view given by Herrick (1895) is that the tegumentary glands of the endopodites of the pleopods secrete an adhesive fluid. However, there are physical aspects which this theory implies that cannot be explained. In the first place, if the eggs became attached as they came in contact with the surface that secreted this adhesive fluid, then some of the eggs should adhere to the endopodite itself. This does not seem to happen, however. In the second place, there are possibilities for the eggs to become attached together in groups around a point. This does not seem to happen either. There are other aspects that point to the unacceptability of the premise.

A different theory is suggested by Williamson. He explains that the endopodite setæ penetrate the chorion of the egg in two places, and thus the egg becomes skewered on the seta. The piercing of the chorion liberates the adhesive perivitelline fluid which assists in making the attachment more permanent, and the egg appears to be attached to the seta by a stalk.

Williamson's theory implies two things: (a) either there must be some kind of a guiding mechanism that enables the seta to pierce the egg in two places or (b) this piercing takes place merely by chance. Since the setæ are very fine and long, they must be in motion constantly, moved by the water currents which must be especially active at the time the eggs are being extruded. The extrusion of the egg itself will cause some water movements. No such mechanism implied in the theory can operate under such conditions. If the piercing of the chorion is just a matter of chance, then the probability is that many of the eggs will be lost, if not the majority of them. Sometimes the number of eggs attached to a seta reaches a hundred or more; the eggs are ranged from the base to the tip of a seta. This condition cannot be possible with the mechanism implied in the theory. Moreover, Williamson's idea about the presence of an adhesive perivitelline fluid is not supported by the findings from cytological studies.

The most plausible explanation seems to be that a sticky substance is secreted around the eggs as they are shed. To the question as to why the eggs do not become attached to the exopodite setæ, the following answers may be given:

(1) The topographical position of the exopodite setæ, their being on the outside, reduces the chances for the eggs to become attached to them.

(2) The eggs on being released outside, first come in contact with the endopodite setæ, which are so thick that they form a sort of an impenetrable barrier. Their tangled mass affords the eggs all chances of becoming attached, and at the same time help keep them within the confines of the entanglement.

(3) The structural make-up of the exopodite setæ and their peculiar arrangement render them less adapted for the attachment of the eggs. They are shorter and finer, and possess side branches (Plate 1, fig. 5, *b*). These branches interlock forming a more or less compact surface, and together with the broad expanded surfaces of the exopodite stalks, a sort of a wall is formed, guarding the sidespaces between the sternal wall and that of the abdomen, when the latter is drawn away from the cephalothorax during the act of spawning. In other words, a sort of basket is formed with the abdomen serving as the bottom and the exopodite stalks and their setæ form the wall. One has only to see a berried crab in order to form an idea, that the exopodites and their setæ are structural devices adapted to act as barriers.

There are other factors that prevent the eggs from attaching to the exopodite setæ, namely: (1) the mobility of the exopodites due to their being loosely joined at the basal segment and (2) the water current. The current set by the movement of the water as it is drawn into the inhalant chamber glides down the sternal wall; its impact upon the broad expanded surfaces of the exopodites spreads the latter outward. The eggs as they glide down within the sternal concavity also produce some water movement. Cross-currents are then produced within the sterno-abdominal space. The interplay of the currents helps to prevent the eggs from attaching to the exopodite setæ and at the same time keeps them within the confine of the sterno-abdominal space amongst the endopodite setæ. The water current also keeps the eggs apart from one another and sets them in motion amongst the setæ until they become at

tached. It is surprising to note that the eggs do not become attached to one another.

The adhesive fluid by means of which the eggs become attached to the endopodite setæ is produced by the secretory cells (Plate 7, fig. 9, *c, c*) of the ovarian follicles. This substance was previously referred to as something collagenous in character. While on their way to the outside, the eggs become coated with this substance which enables them to adhere to the endopodite setæ with which they come in contact. The stalk with which an egg appears to hang on a seta presumably is formed in this manner: the weight of the egg stretches out a portion of this sticky substance and in the meanwhile the action of the water gradually hardens it. Microscopic studies on stained sections of the eggs reveal the presence of a layer of this material around the chorion, and this layer is continuous with the material that forms the stalk (Plate 14, fig. 1, *st*).

DEVELOPMENT

The development may be divided into three stages, namely embryonic, larval and postlarval.

The embryonic development takes place while the egg is attached to the pleopods of the mother. Since the embryonic stage has not been observed in the present study, an attempt will merely be made to give a fragmentary sketch.

Cleavage.—The entrance of the sperm into the germinal vesicle initiates radical changes in this body. It begins to fragment into karyomerites and karyomicrosomes (Plate 10, fig. 3). In the meantime the sperm body also begins to undergo reorganization inside the germinal vesicle. It becomes vesicular and then begins to fragment into karyomerites (Plate 10, figs. 1, *sp*). In this fragmentation process, the idiosome (attraction-sphere) seems to play a very important rôle. It should be recalled in this connection that the idiosome and the acrosome materials form the capsule of the sperm. The fragments of the sperm together with those of the germinal vesicle stream out and this process continues until the germinal vesicle disappears as a body.

The fragments from both the sperm and the germinal vesicle find their way into the cytoplasmic areas scattered amongst the yolk masses. Presumably it is within these cytoplasmic areas where the paternal and maternal elements come into intimate association and where the male and the female pronuclear elements do actually unite.

It is then apparent that syngamy does not take place by the direct bodily fusion of the egg and sperm nuclei; it is effected in a somewhat diffused manner by the fusion of their essential fractional units (karyomerites) in the karyo-cytoplasmic areas. Each zygote-karyomerite resulting from this fractional syngamy seems to influence the active changes that take place around its immediate vicinity.

Starting from those located near the center of the egg, profound changes then take place in the karyo-cytoplasmic areas. They soon begin to form into more or less separate irregular masses, into a number of nonstaining areas, each surrounded by protoplasm; these are the so-called "protoplasmic islands". Some authors consider the protoplasmic islands as cleavage cells, although they are not cells in the sense compared to other types of segmenting eggs. By continuous division, they approach the periphery of the egg and finally unite with the superficial cytoplasmic layer (the blastema). Then the cytoplasmic boundaries become visible and the layer becomes a blastodermic epithelium —the layer assuming the appearance of being divided into plasma blocks (Plate 13, fig. 1). Since the divisions do not extend through the yolk, cleavage in this crab is distinctly superficial.

In each plasma block there is generally present in stained sections a big, heavily stained mass. The presence of this peculiar structure indicates that the blocks are really syncytial masses of cytoplasm and chromatin materials, and possibly including some pigments and other oöplasmic substances. The absence of protoplasmic islands in the vicinity of the heavily stained mass, in sharp contrast to the presence of several of them in blocks that do not contain darkly stained masses, seemingly supports this view.

The term "protoplasmic island" in this sense merely purports the presence of nuclear materials in a mass of cytoplasm, rather than the existence of fully formed nucleus, since its formation is traceable to the inflow of karyomerites of both the sperm nucleus and those of the germinal vesicle into the cytoplasmic area amongst the yolk-masses. The view will hold, if we conceive the idea that these nuclear fragments become reorganized into full-fledged nucleus within the cytoplasmic mass. This idea, however, recognizes total potentiality of a portion (the karyomerite) to reproduce the whole chromosomal complements of a cell. This contravenes the established idea regarding the individuality of chromosomes since a karyomerite is only a fractional portion of a nucleus.

Presumably, what takes place in a cytoplasmic mass is that a karyomerite from the sperm nucleus unites with one from the germinal vesicle of the ovum to form a zygote-karyomerite. This zygote-karyomerite soon undergoes a series of divisions forming a number of daughter karyomerites which then undergo reorganization and become what we may regard as "protoplasmic islands." The formation of plasma blocks may be interpreted as a phase tending toward bringing together what had been scattered before through nuclear fragmentation. In other words, the chromosomal complement that each karyomerite is supposed to carry must be brought together with those borne by the other sister karyomerite before the organization of the nucleus of a cellular unit can proceed; that is, in some sort of a reassociation. The plasma block was previously referred to as a syncytial mass of cytoplasm, chromatin elements, and possibly with some oöplasmic and other materials. The formation of a number of cells from each block in the later stages of development seems to bear out this inference—that the reorganization taking place within the blocks is a counterphase leading to bringing about nuclear reconstruction, and foreshadowing the formation of definitive cellular units.

Some investigators regard the nuclei (karyomerites in this case) that remained in the yolk as "vittelophags," because they assume the special function of the assimilation of the yolk. Around these vittelophags some incomplete boundaries are formed giving rise to what may be called secondary yolk-cleavage. The vittelophags are regarded by some authors as endoderm, and some investigators have described superficial cleavage as leading directly to the formation of a gastrula-like stage, since two kinds of cells, ectodermal and endodermal, develop about the same time.

Some authorities classify superficial cleavage into two groups: (1) cleavage at first total but later superficial; (2) cleavage purely superficial. Both groups may again be divided into two subdivisions, namely: (a) the blastomeres forming on all sides simultaneously and (b) the blastoderm in the ventral side developing precociously.

Cleavage in these crabs (*S. tranquebarica*) is purely superficial, and may be classed under the second subdivision; that is, the blastoderm in the ventral region develops precociously (Plate 13, fig. 2). The character of the cleavage is determinative; that is, the cytoplasm of the egg and the regions are clearly organized in relation to their future destiny.

The egg is ovate in outline, the narrower end being the future anterior part of the body. There seems to be more cytoplasmic masses in the presumptive ventral side, but fewer yolk-masses; whereas, in the presumptive dorsal side the yolk-masses appear to be more numerous. Perhaps the precocity in the development of the ventral side can be attributed to the presence of more cytoplasmic masses, in which region the process of development is less hinderd by the yolk material.

MOVEMENTS OF PARTS DURING DIFFERENTIATION

The movements of protoplasm are quite discernible and at least from the mechanical point of view they may throw some light on certain features of development.

The ovarian egg has its cytoplasm in a delicate superficial layer (blastema) and in numerous delicate intravitellar strands connecting this with the cytoplasmic layer around the adcentral germinal vesicle. In some places among the yolk-spheres, the cytoplasm collects in masses forming what we may term "cytoplasmic areas." These partake the nature of outposts where the karyomerites of the male and the female pronuclei presumably meet and unite. After fertilization these areas become "karyo-cytoplasmic" masses; starting from those located at the center, these masses soon undergo division, giving rise to numerous protoplasmic islands.

The cleavage of the eggs consists of movements leading to the transposition of both nuclear and cytoplasmic materials to the surface. This is in a sort of general cytoplasmic movements of the nature of either a flowing or a contraction. The latter movements are in part upon the yolk surface; in part they consist of movements of vitellocytes within the yolk, but they are blastodermic and not vitellar.

Cleavage in this crab does not lead to a definite blastula and gastrula formation. These two stages, ordinarily occuring as distinct phases, are indistinguishable in this case.

The early blastoderm consists of a peripheral layer of plasma blocks (Plate 13, fig. 1). The ventral germ-disc becomes established by more rapid formation of plasma blocks, and to a certain extent by the apparent rapid migration of protoplasmic islands towards this side. Cell membranes begin to appear while the germ disc is forming; prior to this time the vitelline membrane and the cytoplasm represented one great reticular syncy-

tium, composed of more or less definite masses, the "plasma blocks".

In the absence of definite cell wall and of definite nuclear body, the term "plasma block" is quite appropriate for these masses. They soon, however, give rise to cells with distinct membranes. While this is taking place around the periphery, plasma blocks are also formed within the embryo. The rate of proliferation in the peripheral plasma blocks differ; consequently, the embryo appears to be divided into independent territories wherein active changes are taking place.

Growth differences between cephalothorax and abdomen.—The cephalothorax and abdomen show certain striking differences in their growth and differentiation. The boundary between the two can be recognized as a thin region of the ectoblast where a certain degree of insinking takes place and active proliferation of the cells in the adjoining regions (Plate 14, fig. 1) appears to take place.

Nearly the whole extent of the cephalothorax is laid down, thereafter to lengthen but little more, when the abdomen is represented only by a small lobe (Plate 14, fig. 1, *c. l*). With the segmentation of the mesoblast the abdomen commences to increase rapidly in length, pushing around the yolk until the caudal lobe finally comes in contact with the head lobe. Its growth is teloblastic, and the successive segments formed from its anterior end caudal. This rapid elongation of the abdomen explains why the caudal lobe is narrower than the cephalic lobe. Segmentation becomes more distinct in the abdomen (Plate 14, fig. 2, *ab*).

Protozoea (Plate 14, fig. 3).—Hatching takes place at this stage. The large paired eyes are present; there are no frontal or dorsal spines. The abdomen is well defined, but only five somites and the telson are distinguishable. The sixth somite is still fused with the telson; the latter forked with strong spines in each branch. All the cephalic and the first two pairs of thoracic limbs are present. The antennule consists of a basal segment from which arise two branches and each fork is armed with rather long setæ. Antenna consists of two segments with a few terminal setæ. It is postoral in position. Apparently during the stage of reversion it is shifted anterior to the mouth. The mandible is a small plate. The first and second maxillæ are similar. The first and second pairs of maxillipeds are large and biramous. The protopodite is large and the en-

dopodite and the exopodite have few setæ. As shown in the illustration, the cuticular covering is becoming loose; apparently this indicates that the larva is about to change into the zoea stage.

LITERATURE CITED

1. Nichols, Louise M. Comparative studies in crustacean spermatogenesis. Jour. Morph. **20** (1909) 461–478.
2. Binford, Raymund. The germ cells and the process of fertilization in the crab, *Menippe mercenaria*. Jour. Morph. **24** (1913) 147–200.
3. Pearson, Joseph. Cancer. Liverpool, Marine Biological Committee. No. 16 (1908) 1–207.
4. Wilson, Edmund B. The cell in development and heredity (1928).
5. Doncaster, Leonard. An introduction to the study of cytology (1924).
6. Darlington, C. D. Recent studies in cytology (1937).
7. Richards, Aute. Outline of comparative embryology (1931).
8. Huxley, T. H. The crayfish (1906).
9. Herrick, F. H. The american lobster. Bull. U. S. Fish Comm. (1895).
10. Arriola, F. J. A preliminary study of the life history of *Scylla serrata* (Forskål). Philip. Jour. Sci. **73** (1940) 437–454.
11. Williamson, H. C. Twenty-third report, Scotch Fishery Board.
12. Koltzoff, N. K. Studien über die Spermien der Decapoden, als Einleitung das Problem der Zellengestalt. Arch. f. mikros. Anat. Bd. **67** (1906).

ILLUSTRATIONS

Plate 1

Fig. 1. Ovigerous female, with chelipeds removed. *g. o*, genital opening; *i o*, inhalant opening.

2. Ovaries, X 1. *c*, chitinous portion of the spermatheca; *g*, grandular portion of the spermatheca; *g, m*, gonadial membrane; *od*, oviduct; *ov*, posterior extension of the ovaries; *ov. f*, ovarian follicle; *spt*, spermatheca; *v*, vulva.

3. Cross-section of ovary through region above chileped, X 2. *bv*, blood vessel; *c*, canal formed by the ligamental fold; *d.w*, dorsal wing; *t*, one of the follicular tubules; *v.w*, ventral wing.

4. Abdomen of female *S. tranquebarica*, showing character of segmentation, X 1.

5. Second abdominal appendage, of a female, X 2. *a*, coxopodite; *b*, basipodite; *en*, endopodite; *ex*, exopodite; *s*, fringe of setae.

6. Portion of exopodite seta, showing dendritic characteristic, X 600.

Plate 2

Fig. 1. Abdomen of male *S. tranquebarica*, showing character of segments, X 1.

2. First abdominal appendage of male, modified as copulatory apparatus; left side, inner surface, X 2. *a*, basal joint; *b*, groove; *c*, cisterna spermatica; *d*, excavated area; *e*, groove along funnel tube.

3. First abdominal appendage of male, modified as copulatory apparatus; right side, outer surface, X 4. *a*, tip of the funnel tube; *b*, free edge of rolled portion of tube; *d*, canal leading to mouth of tube.

4. Second abdominal appendage, also modified as copulatory apparatus. Right side, dorso-lateral surface; enlarged. *c*, canal in the fork; *f*, fork; *mf*, membranous fold.

5. Second abdominal appendage, terminal portion only, inner surface to show the spinules on trough of fork, enlarged.

6. Testes X1. *ed*, ajaculatory duct; *f*, follicular tubule; *gm*, gonadial membrane; *ps*, pedal sinus; *te*, testis; *vd*, vas deferens.

7. Two epithelial cells from lining of lumen of ejaculatory duct, X 1350, camera lucida. *a*, attachment; *b, co*, basal corpuscle to each cilium; *c*, cilia; *cb*, cell body; *f*, fibrils corresponding to each cilium; *n*, neck.

Plate 3

Fig. 1. A growing auxocyte in follicular tubule of testis of *S. tranquebarica*, X 1350, camera lucida.

2. A pro-spermatid undergoing reorganization. The spiremes radiating from heterochromosomes, the darkly stained mass at center of germinal vesicle, X 1350, camera lucida.

3. A pro-spermatid undergoing further reorganization. The spiremes are transformed into chromatids and their groupings indicate tetrad formation, X 1350, camera lucida, *l*, a pair of tetrads.
4. Pre-synaptic stage, showing number of chromosomes and pairing, X 1350, camera lucida. *h*, heterochromosomes (the XY-pair); X-chromosome in form of loop, Y-chromosome small; *m*, monosome.
5. Chromosomes in synaptic stage; appearance of the idiosome and acroblasts, X 1350, camera lucida. *h*. heterochromosomes; *i*, idiosome; *m*, monosome; *p. ac*, pro-acrosome granules.
6. Pro-spermatid body in process of reorganization, showing concentration, contraction and sloughing-off of materials, X 1350, camera lucida. *ac*, acroblast (central body); *g*, Golgi-bodies remnant; *i*, idiosome; *ne*, nuclear extrusion.
7. Pro-spermatid undergoing concentration and contraction; X 1350, camera lucida. *i*, idiosome; *m*, monosome, the extra X-chromosome. The chromosomes are now dyads and the acroblast body has disaggregated.
8. Formation of definitive spermatid body; sloughing-off of residual protoplasm and diminution of both nuclear and acroblast materials, X 1350, camera lucida. *c.e*, possibly cast-off nuclear or acroblast materials; *i*, idiosome; *r.p*, residual protoplasm; *sp.b*, spermatid body; *x*, sex-chromosome.
9. Spermatid undergoing abortive mitotic division involving largely the nucleus; this results in neiosis, X 1350, camera lucida. *ac*, acroblast; *d*, daughter nucleus; *m*, probably the extra X-chromosome (monosome).
10. Top view of spermatid, wherein process of concentration is going on, X 1350, camera lucida. *ac*, acroblast; *i*, idiosome.
11. Side view of spermatid in contraction phase, X 1350, camera lucida. *ac*, acroblast; *r.p*, residual protoplasm.
12. Basal-side view of spermatid undergoing concentration, X 1350, camera lucida. *ac.r*, acroblast-remnant.
13. Basal portion of spermatid, showing number of chromosomes, X 1350, camera lucida.

14–18. Later phases of transformation characterized by peculiar behavior and movement of acrosome body, X 1350, camera lucida.

19. Spermatozoön, X 1350, camera lucida. *ca*, capsule; *nc*, nuclear cup.

Plate 4

Fig. 1. Developing auxocyte (of class without tetrads), drawn from cross-section of follicular tubule, X 1350, camera lucida. *f*, follicular wall; *ch.n*, chromatin nucleolus; *n.nc*, presumably nucleus of nurse cell.

2. Surface view of auxocyte (without tetrads), X 1350, camera lucida. *n.c*, nurse cell.
3. Side-view of auxocyte (without tetrads), at termination of growth period, X 1350, camera lucida. *f*, follicular wall.
4. Chromosome pairs of auxocytes without tetrad formation, X 1350, camera lucida. *h*, heterochromosomes (possibly XY-pair).

5. Showing two spermatids that have differentiated from auxocytes (of class with no tetrad formation), X 1350, camera lucida. *ac*, acroblast; *g*, Golgi-bodies remnant; *n.c*, nurse cell; *n.e*, nuclear extrusion; *sp*, spermatid body; *v.ac*, acroblast vesicle.

6–10. Later phases of transformation of spermatids (of class with no tetrad formation), X 1350, camera lucida. *ac*, acroblast; *ac.r*, acroblast-remnant; *ca*, capsule; *i*, idiosome; *n.c*, nuclear cup.

Plate 5

Fig. 1. Group formation of auxocytes (spermatocyst), X 1350, camera lucida. *cys*, cyst; *sp*, spermatoblast (auxocyte).

2. Auxocyte from group formation (spermatocyst), showing chromosomes, X 1350, camera lucida. Y-chromosomes (*y*) is small, apparently triosomic and attached to big X-chromosome.

3. Auxocyte of *S. oceanica*, in which nucleus has split into two spermatid nuclei, X 1350, camera lucida. *a*, attraction sphere; *c*, centriole; *f*, follicular wall; *sp. n*, spermatid nucleus.

4. Spermatid that has developed from spermatid nucleus, X 1350, camera lucida.

5–7. Some phases of transformation of spermatid (in *S. oceanica*) to spermatozoa, X 1350, camera lucida. *ac*, acroblast; *ac.r*, acroblast remnant; *i*, idiosome.

8. Spermatozoa (*S. oceanica*), X 1350, camera lucida. *a*, Basal-side view; *b*, Basal portion only.

9–10. Chromosomal complement (*S. oceanica*), X 1350, camera lucida.

11. Pro-spermatid of *paramamosain*, showing nuclear diminution and sloughing-off of some cytoplasmic material, X 1350, camera lucida.

Plate 6

Fig. 1. Somewhat more abbreviated process of pro-spermatid differentiation from auxocyte (in *paramamosain*), X 1350, camera lucida.

2. Formation of two spermatids from pro-spermatid body, X 1350, camera lucida.

3–4. Some phases of transformation leading to formation of spermatozoa, X 1350, camera lucida.

5. Spermatozoa, X 1350, camera lucida.

6. Photomicrograph showing spermatocyst of *S. serrata*, X 400. Note that some spermatids appear in pairs.

7–8. Process of reorganization in nucleus of auxocyte (of *S. serrata*) leading to differentiation of spermatid, X 1350, camera lucida. *c*, centrosome with some centroplasm.

9. Differentiation of spermatid nucleus from auxocyte nucleus (in *S. serrata*), and sloughing-off of some material, X 1350, camera lucida. *r. p*, sloughing-off material.

10–12. Phases of nuclear reorganization in auxocyte nucleus (in *S. serrata*), tending toward differentiation into two spermatid nuclei, X 1350, camera lucida.

PLATE 7

FIG. 1. Phases of nuclear reorganization in auxocyte nucleus (in *S. serrata*), tending toward differentiation into two spermatid nuclei, X 1350, camera lucida.

2. Nucleus, with chromosome-nucleolus at equatorial region prior to its splitting, X 1350, camera lucida.

3. Division, X 1350, camera lucida. *cy*, portion of cytoplasm of auxocyte; *i*, idiosome.

4. Side view of remains of auxocyte; the spermatids are still within, X 1350, camera lucida.

5–7. Later phases of spermatid transformations, X 1350, camera lucida.

8. The spermatozoön, X 1350, camera lucida.

9. Cross-section of ovarian follicle, X 600, camera lucida. *c*, some collagenous material in lumen of follicle; *c.c*, collagen-forming cells; *f*, follicular wall; *l*, lumen of follicle; *n*, nurse cell; *o*, growing oöblast (auxocyte).

10. Two developing auxocytes together with some nurse cells, from section of surface of ovarian tubule of *S. tranquebarica*, X 1350, camera lucida.

11. Developing auxocyte together with some nurse cells, from cross-section of ovarian tubule of *S. tranquebarica*, X 1350, camera lucida. *f*, follicular wall; *n. c*, nurse cell; *a*, developing oöblast (auxocyte).

PLATE 8

FIG. 1. Auxocyte at termination of growth period, X 1350, camera lucida. *cn*, chromatin-nucleolus; *g*, Golgi-bodies; *n*, germinal vesicle; *nc*, vestiges nurse cells; *v*, vitellogenous or pallial substance.

2. Ovocyte in pachytene stage of contraction phase, X 1350, camera lucida. Irregularly scattered spherules appear in place of pallial substance.

3. Diploid number of chromosomes, supernumerary chromosomes and diminution of nuclear materials, X 1350, camera lucida. *h*. hetero-chromosomes, evidently XX-pair.

4. Ovocyte, showing extrusion of first polar body, X 1350, camera lucida. *p.b*$_1$, first polar body.

5. Ovocyte apparently in contraction phase, after formation of first polar body, X 1350, camera lucida.

6. Pairing of chromatid groups prior to meiotic division which involves nucleus only, X 1350, camera lucida. *h*, hetero-chromosomes; *m*, monosome; *p. pb*, path of first polar body.

7. Chromosomes in secondary pairing prior to meiosis, X 1350, camera lucida. *h*, hetero-chromosomes; *a.s*, attraction sphere with two division centers; *m*, monosome.

8. Meiotic division involving germinal vesicle only, X 1350, camera lucida. This will result in formation of second polar body.

9. Ovocyte with germinal vesicle divided into two daughter nuclei, X 1350, camera lucida. *p. b*$_2$, the second polar body.

10. Young ovum with second polar body still within its body, X 1350, camera lucida. The egg pronucleus is turning around towards center.

11. Young ovum showing penetration of sperm into oöplasm, X 1350, camera lucida. *ch*, chorion; *m*, path of penetration; *ps*, perivitelline space; *sp*, sperm body; *v*, vitelline membrane.

PLATE 9

Fig. 1. Ovocyte (of class with no tetrad formation) differentiating from auxocyte body, X 1350, camera lucida. *g*, Golgi-bodies; $p.b_1$, first polar body.

2. Extrusion of first polar body, X 1350, camera lucida. Both ovocyte and polar nucleus still within auxocyte body. *a*, attachment of the auxocyte to the follicular wall; *h*, hetero-chromosomes; *p.n*, polar nucleus; *o*, ovocyte.

3. Fertilized ovarian ovum (macro-ovum), X 900, camera lucida *b*, peripheral cytoplasmic layer (blastema); *ch*, chorion; *cy*, cytoplasmic mass; *g.v*, germinal vesicle; *sp*, sperm vesicle; *y*, yolk-sphere.

PLATE 10

Fig. 1. Germinal vesicle of macro-ovum, with sperm inside, X 1350, camera lucida. Sperm evidently undergoing reorganization. *cy*, cytoplasmic layer around the germinal vesicle; *cs*, cytoplasmic strand; *sp*, sperm body.

2. Germinal vesicle of growing micro-ovum, X 1350, camera lucida. *cs*, cytoplasmic strand; *cy*, cytoplasmic layer around germinal vesicle.

3. Germinal vesicle of full-grown micro-ovum; with a sperm within, X 1350, camera lucida. *cs*, cytoplasmic strand; *cy*, cytoplasmic layer; *e*, penetration path of the sperm; *k*, karyomerite; *m*, microsome; *sp.n*, sperm nucleus.

4. Remaining portion of germinal vesicle undergoing fragmentation, X 1350, camera lucida. *k*, karyomerite; *ks*, karyoplasmic streamer.

5. Sperm body within germinal vesicle becoming vesicular preparatory to fragmentation, X 1350, camera lucida.

6. Sperm body within germinal vesicle fragmenting into karyomerites, X 1350, camera lucida.

7. Ovocytes differentiating from auxocytes (in *banhawin*), X 1350, camera lucida. *c*, centrosome; $p.b_1$, first polar body; *i.dc*, intranuclear division center.

8. Young ova in different phases of growth, X 1350, camera lucida. *e.dc*, extra-nuclear division center; *i.dc*, intra-nuclear division center; *sp.* sperm after penetration.

PLATE 11

Fig. 1. Young ova, X 1350, camera lucida. *sp*, sperm that has penetrated.

2. Photomicrograph of a large portion of mature ovum, X 900. Note sperm within germinal vesicle.

3. Full-grown macro-auxocyte of *paramamosain*, in the contraction-figure, X 1350, camera lucida. *c*, centrosome with some centroplasm.

4. Diffused stage, tending toward diminution of karyoplasmic material preparatory to differentiation of the ovocyte, X 1350, camera lucida. *c*, centrosome.
5. Second synizesis, or contraction-figure, showing differentiation of ovocyte from auxocyte body, X 1350, camera lucida.

PLATE 12

FIG. 1. Micro-auxocyte, in contraction-figure, or synizesis, X 1350, camera lucida. Nuclear material undergoing rearrangement preparatory to differentiation of ovocyte.
2. A contraction-figure in advance stage; nucleus undergoing abortive division, X 1350, camera lucida. *c*, centrosome.
3. Micro-ovocyte that has differentiated from auxocyte body, X 1350, camera lucida. *p.n.* polar nucleus.
4. Photomicrograph of portion of ovary of *paramamosain*, X 900. *f*, follicular wall; *mi*, micro-ovum; sp_1, sperm outside of egg; sp_2, sperm within egg but still outside the germinal vesicle; sq_3, sperm inside germinal vesicle; *v*, vitellogenous layer.
5. Auxocyte of *S. serrata* (from an immature individual) showing contraction-figure, or synizesis, after growth period, X 1350, camera lucida.
6. Ovocyte differentiating from auxocyte body, X 1350, camera lucida. *p.n*, polar nucleus.
7. Ovocyte wherein processes of concentration and contraction are apparently going on, X 1350, camera lucida. *c*, centrosome with some centroplasm; *p.n*, polar nucleus.
8. Ovocyte in contraction phase, showing sloughing-off of some material, X 1350, camera lucida. $p.n_1$, first polar nucleus; $p.n_2$, second polary body.

9-10. Chromosomal constitution, X 1350, camera lucida. *x*, apparently X-chromosome.

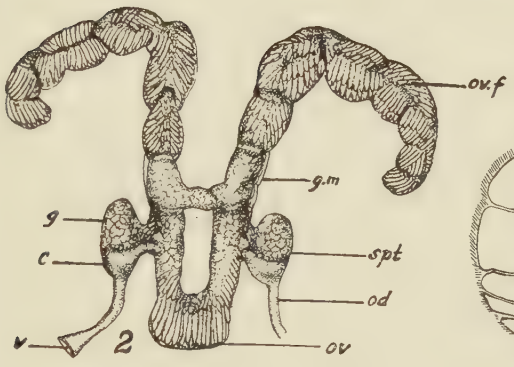
PLATE 13

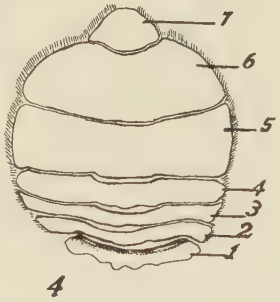
FIG. 1. Egg undergoing cleavage (*S. tranquebarica*), X 900, camera lucida. *1*, presumptive head region; *2*, presumptive dorsal region; *3*, ventral region; *ch*, chorion membrane; *b*, plasma block; *p*, blastema; *p.s*, perivitalline space; *s.f*, secondary yolk-cleavage furrow; *v*, vitelline membrane.
2. Eggs in different stages of development, still attached to the endopodite setæ, X 150, camera lucida. *c*, collagenous material attaching egg to seta; *ch*, chorion membrane; *p.b*, polar body; *s*, seta; *st*, stalk drawn out from layer of collagenous material around egg.

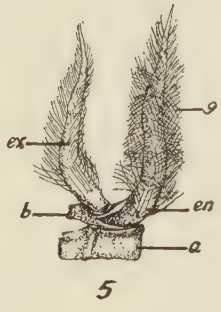
PLATE 14

FIG. 1. Outline drawing of embryo, showing growth differences between cephalothorax and abdomen, X 900, camera lucida. Only plasma blocks along periphery are drawn. *c.l*, caudal lobe; *ch*, chorion membrane; *c.m*, layer of collagenous material; *p.l*, procephalic lobe; *st*, stalk formed from collagenous material that enables embryo to attach to endopodite setæ; *th. l*, thoracic lobe.

2. Early protozoea, X 150, camera lucida. *ab*, abdomen; *e*, eye; *t*, telson.
3. Later protozoea stage, X 150, camera lucida. *a-1*, antennule; *a-2*, antenna; *e*, eye; *m*, mandible; *mx-1*, first maxilla; *mx-2*, second maxilla; *mp-1*, first maxilliped; *mp-2*, second maxilliped; *t*, telson; *1–5*, abdominal segments.







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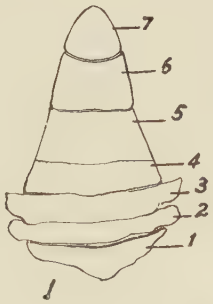

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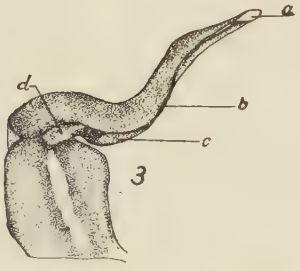

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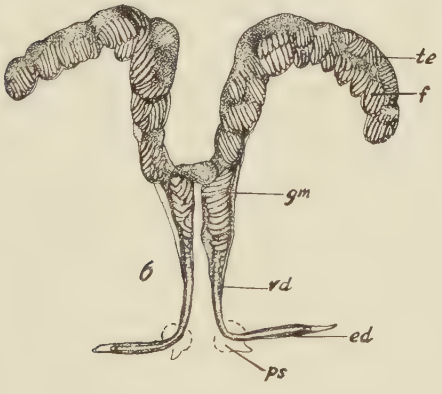

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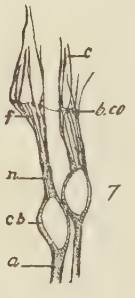

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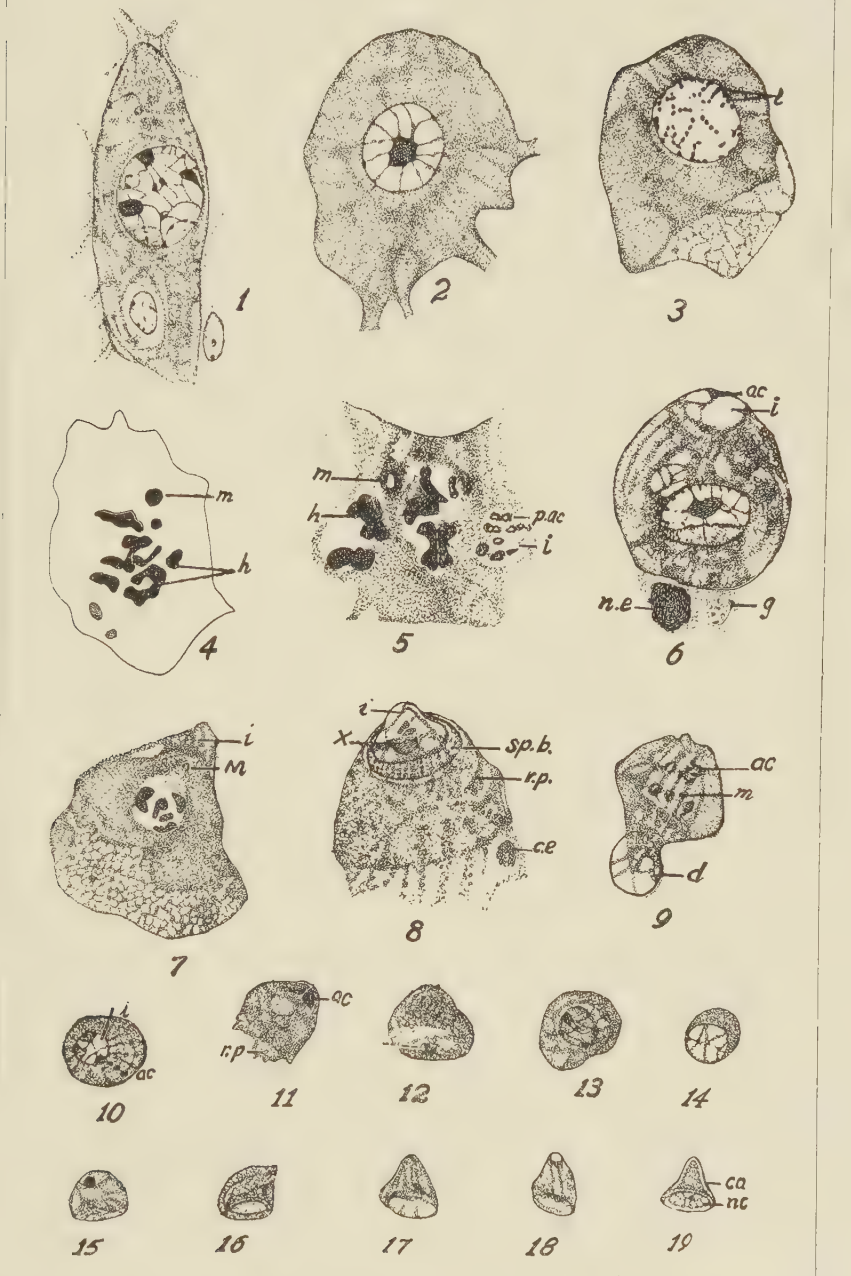
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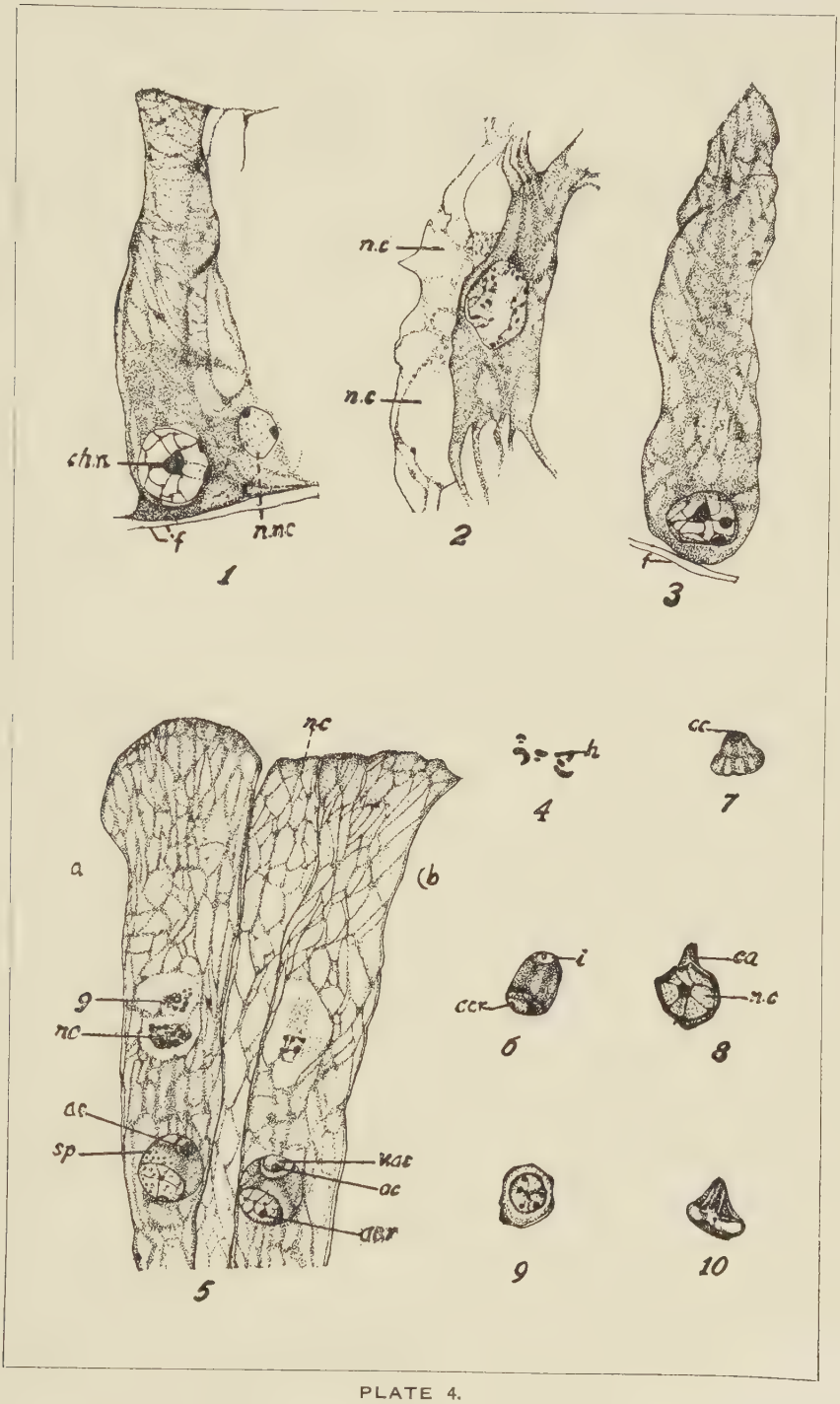
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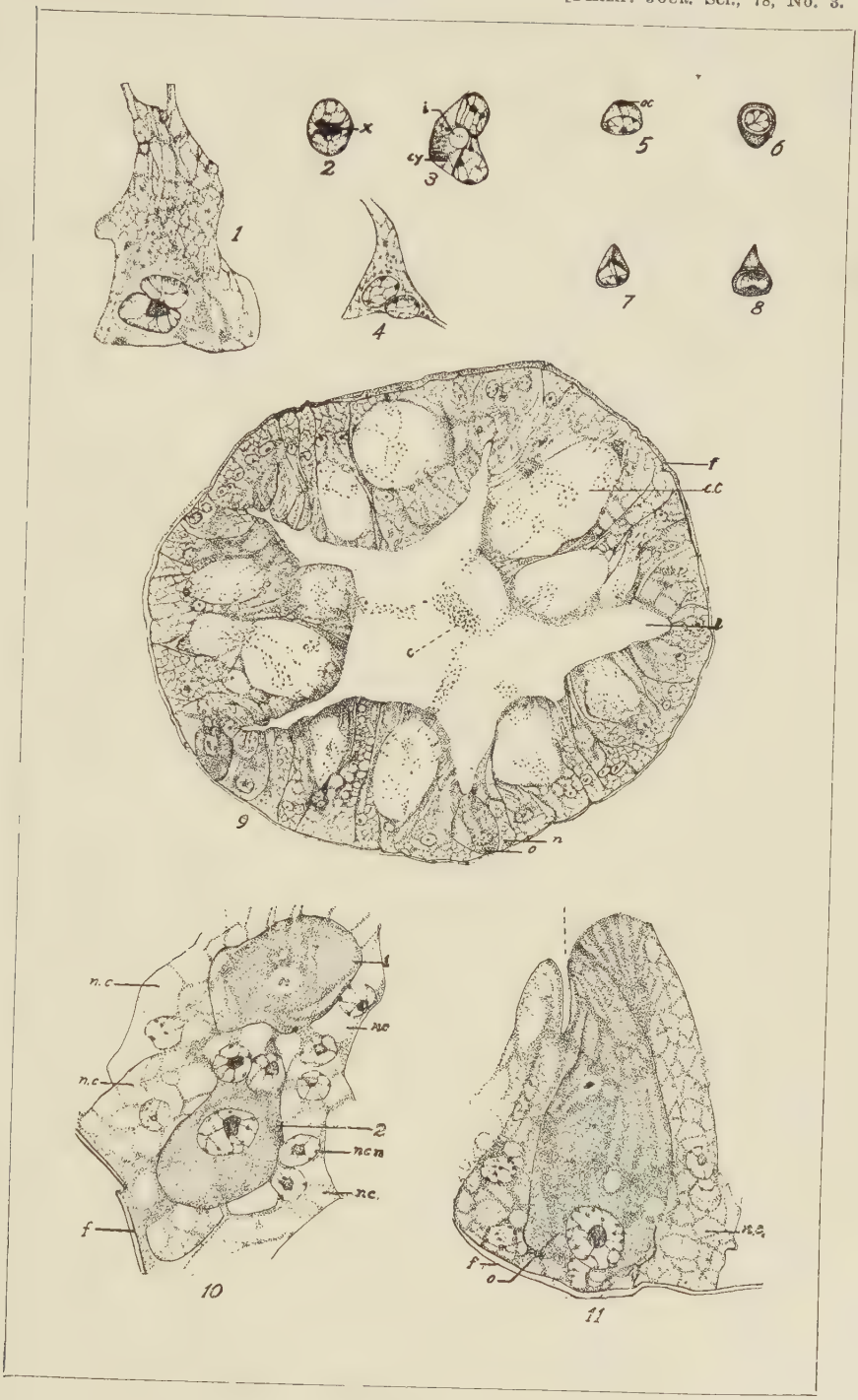
PLATE 4.

PLATE 5.

PLATE 6.



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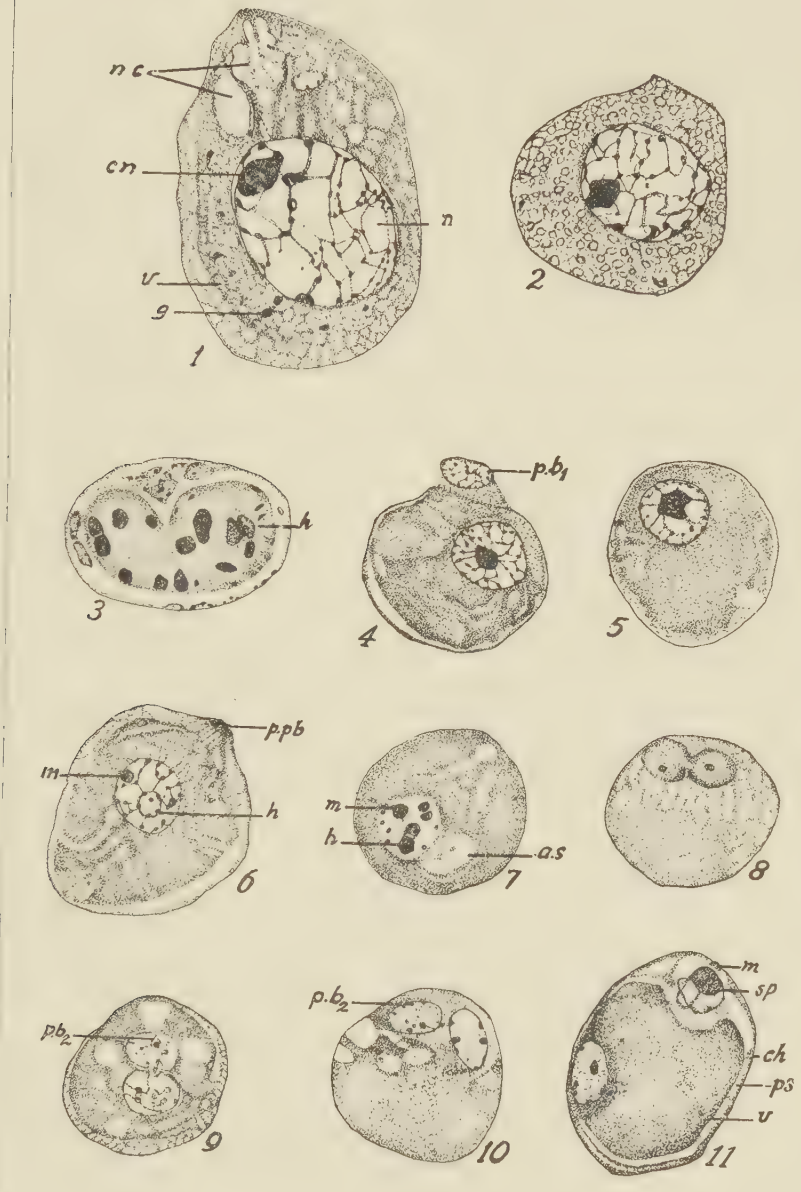

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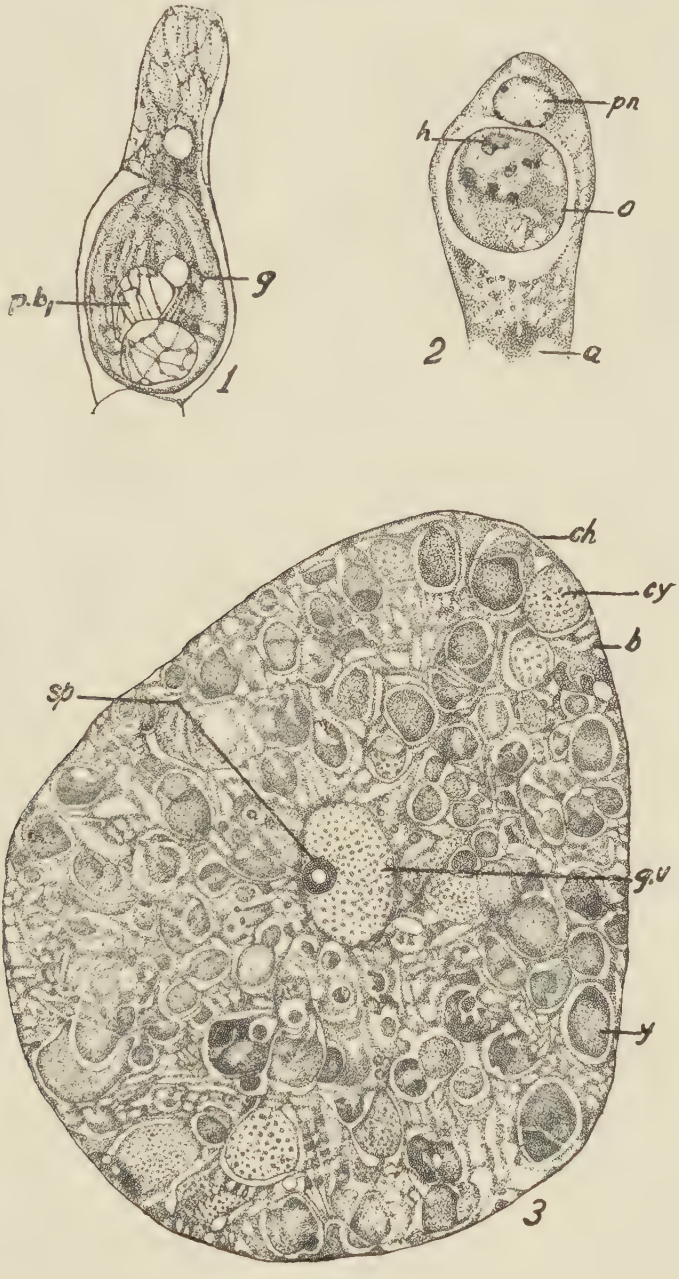

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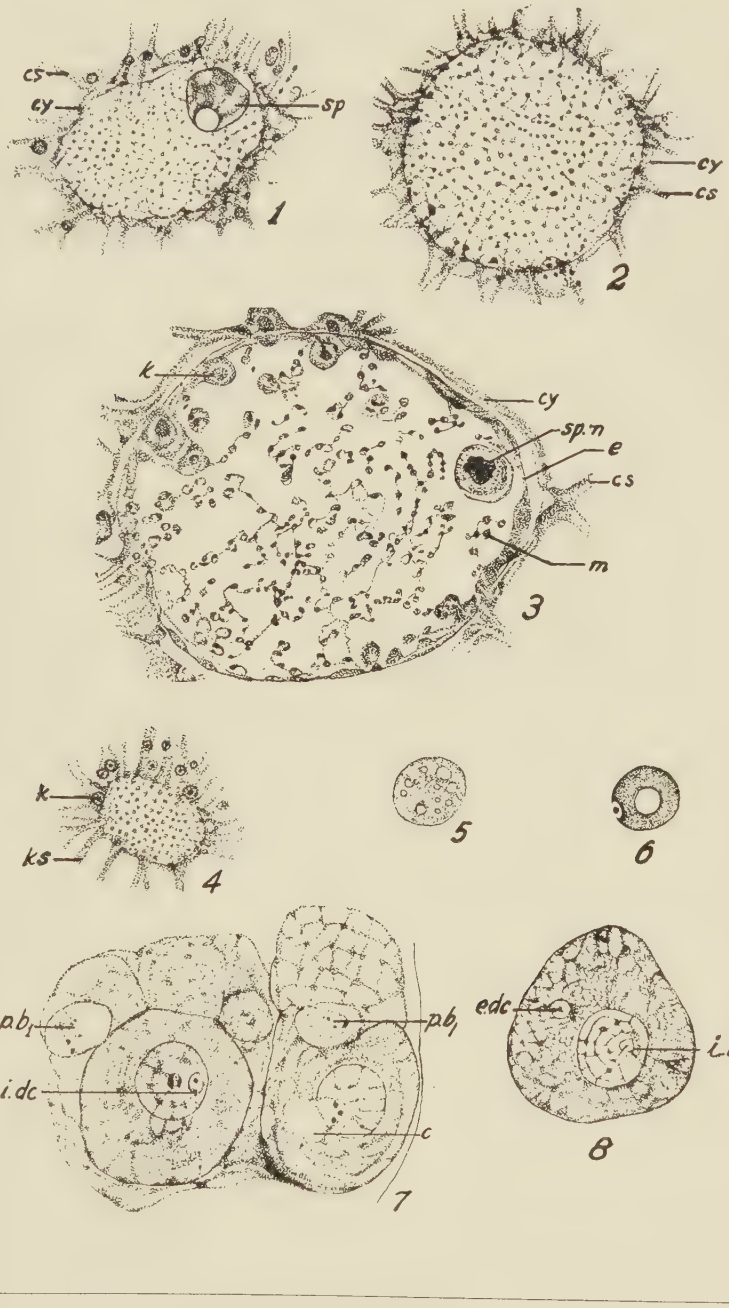

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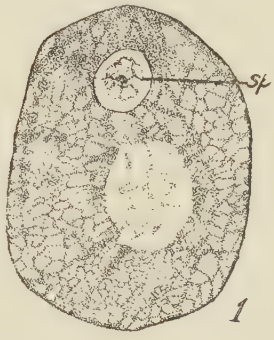

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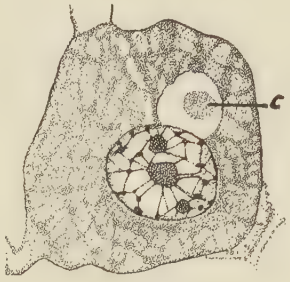

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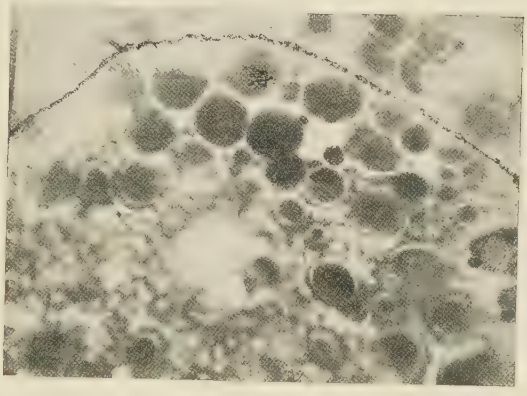

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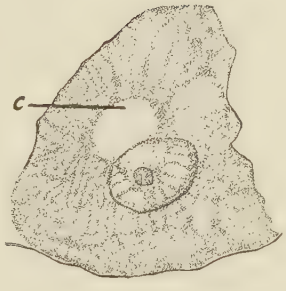

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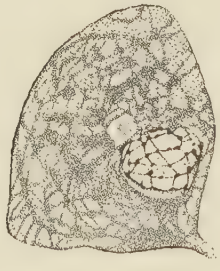

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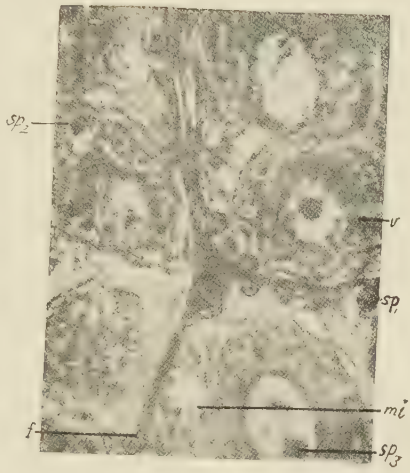

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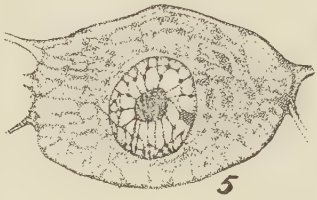

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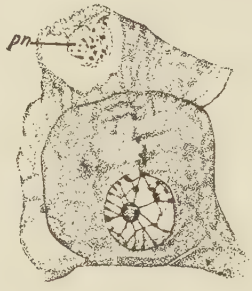

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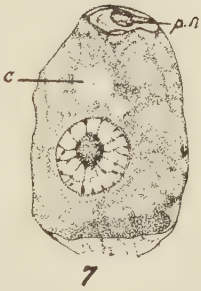

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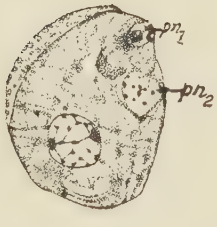

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PLATE 12.

PLATE 13.

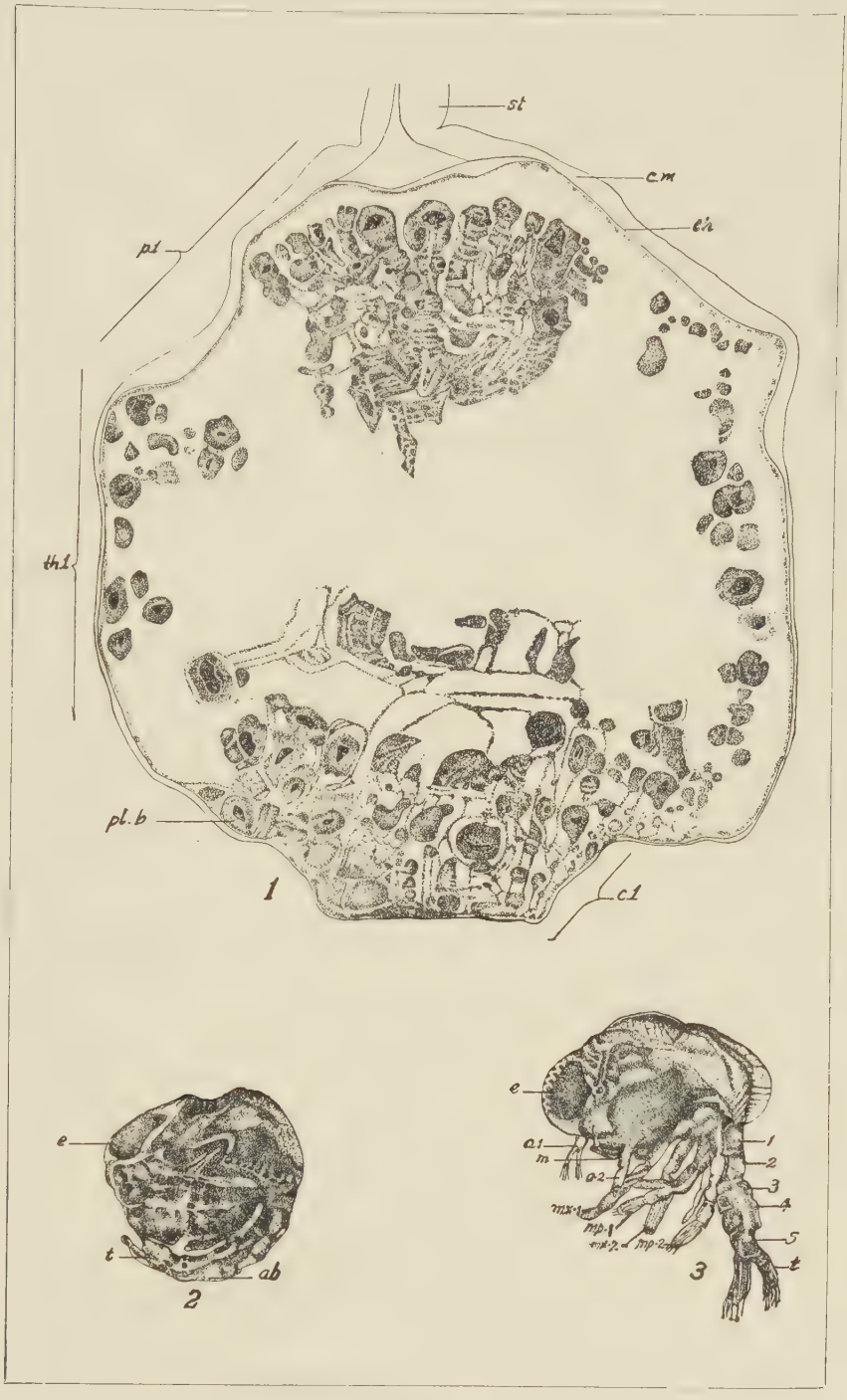

PLATE 14.

SUITABILITY OF MANILA HEMP WASTE FOR PAPER MAKING MATERIAL

I. PULPING OF MANILA HEMP WASTE BY THE SODA PROCESS

By MARIANO P. RAMIRO *

Formerly, Fellow, Office of International Information and Cultural Affairs, Department of State, U.S.A.

Abaca (Manila Hemp) waste is available in large supply in the Philippines and is a source of useful fibers that could be converted into valuable products of commerce and industry. This investigation was carried out to determine the most suitable conditions for reducing this material into pulp of good yield, strength and color.

The term "manila hemp" is commonly applied to the fiber extracted from the leaf-stalks of *Musa textilis* Née (family *Musaceæ*), a plant indigenous to the Philippines. The plant which is locally called "abaca," shoots from its underground rootstock spurious stems consisting of concentric sheating leafstalks. The stalk attains a height of 15 to 20 feet in 1½ years and spreads out into large undivided leaves. Clusters of from 12 to 20 stalks are developed from each rhizome. In its native habitat, particularly the southern regions of Luzon, abaca grows well with the least cultivation and care.

"Abaca" is sufficiently matured for stripping at flowering age. The stalk is cut down and the outer fiber-bearing layer of each successive leaf-stalk is divided or torn into ribbons of from one to two inches wide and about one-fourth of an inch thick. While fresh and succulent, the ribbons are scraped with a knife-block stripping device to render the fiber free of the soft cellular materials that surround the fiber strands. The

* The author wishes to extend his appreciation to the Office of Intertional Information and Cultural Affairs of the U. S. Department of State for its support in carrying out this work; to the Forest Products Laboratory, Madison, Wisconsin, for furnishing the facilities; to John Manning Paper Company, Inc., for furnishing the information on pulping Manila hemp; and to Messers, Mark W. Bray and John S. Martin, Forest Products Laboratory, for their advice and assistance in planning the experiments herein reported.

extraneous material is called abaca bagasse or the plantation waste of the abaca industry.

LITERATURE

Acid sulfite pulping of abaca bagasse waste [3] results in the retention of most of the cellular constituents in the pulp. This type of pulp is suitable only for paper where strength is of primary consideration, but not paper for which color is essential.

The conventional manila hemp for rope manufacture, and to some extent as base material for plastic articles, is usually clean and of high quality. It is perhaps on this account that the pulp yield from old manila rope by the caustic soda, soda ash and lime-soda ash processes is higher than the yield from rope factory waste [5] and low grade abaca fiber. Papers made from the factory waste are found also to be inferior to those from old rope stock.

By digesting manila hemp with a strong solution of caustic soda at 320 degrees Fahrenheit Osborne [2] obtained non-hydrated pulp which was converted into thin paper suitable for stencil base, condenser, and tissue paper. Shaw and Bicking [5] found that cooking wth soda ash gave satisfactory results as to pulp yield and quality of paper from rope stock.

The use of abaca in the paper industry dates back to the American civil war [4] when the production of cotton fell so low that the price of cotton bagging which was used exclusively for transporting flour and other articles prior to the war became prohibitive. Flour bag substitute was then an urgent problem. It was not very long, however, before paper of exceptional strength and durability was prepared from old rope stock to replace the cotton bag. The paper known commercially as manila paper has been so successfully manufactured from old rope that it has become an important material for the transportation of food articles, cement and other commodities. The convertibility of manila hemp into various types of paper is responsible for the increasing interest and demand of the fiber by many industries.

SOURCES AND PHYSICAL PROPERTIES OF THE MATERIAL

The sample of abaca waste, consisting of fifteen bales weighing about 150 pounds each which was used for these pulping experiments, came from Manila and was received at the Forest Products Laboratory, Madison, Wisconsin, in May, 1946. A

history of the fiber was not received. However, it appeared to be a fairly good rope factory waste, which fell under the T3 quality based on the grading practice of the cordage industry. Besides being dusty, some of the fibers were so badly decayed that they crumpled on handling. Leaves, twigs, and shrub stalks, estimated at approximately one per cent, constituted some of the foreign materials mixed with the fibers. The presence of these undesirable materials, particularly the decayed portions of the hemp, contributed undoubtedly to the low pulp yield.

PULPING EXPERIMENTS

Preparation of material.—In order to eliminate as much as possible the effect of the decayed fibers on pulp yields, only sound material was used in the pulping experiments. Twigs and other foreign matters were also removed but some escaped examination and finally emerged from the digested material as screenings. To overcome the difficulty of sampling and packing the fiber into the digester, the original fiber was cut into convenient sizes of from 2 to 4 inches long.

Equipment.—Digestion experiments were carried out in three autoclaves each consisting of two hollow concentric cast-steel spheres mounted on trunnions. Each autoclave had a convenient opening for charging and discharging and was provided with a removable ground-in cover held in place by a suitable clamp attached to the cooking vessel. Between the spheres there was an annular space serving as a steam jacket for heating the inner sphere. One trunnion was used as an inlet for the admission of steam, or of cooling water to the jacket which may be drained through a pet cock. The other trunnion which projects to the center of the inner sphere served as a thermometer well and also supported a guard for the projecting steam of the thermometer.

Each autoclave was driven by a $\frac{1}{4}$ h. p. geared motor at about one revolution per minute. To the $\frac{1}{2}$ inch steam line leading to the cooking vessel, about a foot from the end of the trunnion, a pressure gauge is installed as a means of showing the pressure of the steam in the steam jacket.

Chemical.—For each digestion, an equivalent amount of the chemical required for a cook was taken from a relatively strong stock solution containing 118 grams of sodium hydroxide per liter.

Procedure.—A sample equivalent to the moisture-free weight of two pounds of the fiber was used in all the digestion

experiments. This quantity of material, when properly packed was sufficient to charge one autoclave to its full capacity of 3.7 gallons (1/2 cu. ft.). The fiber was placed in the digester and the cooking liquor diluted to the proper concentration was added to it. For all the experimental tests, the ratio of the volume of the cooking solution to the moisture-free weight of the fibrous material was 7 to 1. The digesters were rotated throughout the entire cooking period.

During the temperature rise period of one hour, steam was admitted to the jacket at a rate sufficient to effect a uniform rise of temperature. One set of pulping experiments was made at a maximum temperature of 140° C., another at 150° C., and a third at 160° C.

In order to gain an idea of the effect on pulp yield, strength, color of the pulp of digestion temperature and ratio of chemical to raw material, a series of ten cooks was made. The liquor-hemp ratio and the temperature rise schedule were maintained constant. The length of the cooking period was also held constant except in certain instances where it was desired to determine the progress of the reaction under a particular set of conditions. At the end of the digestion, the steam pressure in the jacket was relieved and the autoclave was cooled by allowing cold water to replace the steam in the jacket. The digested material was discharged in a wire-screen-bottom box where the pulp was thoroughly washed. Although the digested material was considerably softened, the fiber bundles were still intact. These were broken up by agitating the raw cooked pulp with a sufficiently large amount of water in a tank provided with an impeller stirrer. The resulting pulp was screened through a one foot square flat vibrating screen with slotted opening of about 0.014 inch wide. The total yield of pulp, the screenings, and the screened pulp were calculated from the moist weight and the moisture content of the materials.

The physical characteristics of the pulp were determined according to the standardized procedure and testing practice of the Technical Association of Pulp and Paper Industry. The average values obtained from the tests are a measure of the quality of the pulp.

DISCUSSION OF RESULTS

The data presented in Table 1 show the pulping conditions employed, pulp yields, and the physical properties of the pulps. In general the strength properties of the pulps were slightly

affected by the several digestion variables including temperature of digestion, concentration of cooking liquor, chemical ratio, and time of cooking. It is apparent that in cases where a light-colored paper is not required, pulps from reasonably mild digestions are almost identical to and consequently just as good as the products obtained under more drastic cooking conditions. Incidentally, the data tend to show that pulping abaca waste for two hours at a maximum temperature of 150° C. with from 12 to 16 per cent caustic soda (cooks 1712 and 1713), based on the moisture-free weight of the raw material, give satisfactory pulps of good bursting, tearing, folding, and tensile strengths. The color of the unbleached pulps obtained under these conditions has a brightness of from 22 to 29 per cent as measured with the Hunter Reflectometer using a blue glass filter and calibrated according to TAPPI Method T–217M45.

An increase in either the concentration of chemicals in the cooking liquor, the chemical ratio, the temperature, or the duration of cooking resulted in a decrease in the permanganate number of the pulps. Pulps with low permanganate number generally have a low bleach requirement.

In order to determine the most suitable conditions for converting the hemp into pulp with reasonably good physical properties, batches of the raw material were digested under a number of cooking conditions using several chemical ratios, concentrations, temperatures and cooking times. For the first trial, cook 1712, an initial set of cooking conditions was arbitrarily selected as a guide for the subsequent digestion experiments. The results show that the screenings were relatively low, an indication that the chemical used was almost sufficient for the complete reduction of the fiber to pulp. A reduction of the chemical ratio from 12 to 8 per cent (cook 1723) resulted in a decrease of from 54.7 to 48.3 per cent in the yield of screened pulp and an increase in screen rejects of from 1.9 to 22.4 per cent. Conversely, as the chemical ratio was increased from 12 to 20 per cent at constant volume and the solution concentration increased from 17.0 to 29.0 per cent there was a correponding decrease in the yield of screened pulp.

A correlation of screened yield and total yield, as affected by the chemical ratio and solution concentration, is indicated in Fig. 1. It will be noted that in the regions of low concentration, the two curves are divergent but they converge at the higher concentrations.

TABLE 1.—*Pulping conditions and properties of abaca* (manila hemp) *pulp*

Digestion number	Hemp		Cooking conditions and yield data										Interpolated test-beater strength data (Unbleached pulp) 75° C. and 50 per cent relative humidity							Permanganate number	Brightness (unbleached pulp)
			Caustic soda			Duration at maximum temperature	Maximum temperature [1]	Chemical consumed			Yield moisture-free pulp										
	Moisture	Moist weight	Total concentration	Per 100 pounds moisture-free hemp	Volume of liquor per 100 pounds moisture-free hemp			Total chemical	Based on moisture-free hemp	Density of black liquor at 15° C.	Screened	Screenings	Freeness, Schopper-Riegler	Time of treatment	Density	Bursting strength	Tearing resistance	Folding endurance	Tensile strenght		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
	Per cent	*Lb.*	*Grams per liter*	*Lb.*	*Gallons*	*Hrs.*	°C.	*Per cent*	*Per cent*	*Be.* [1]	*Per cent*	*Per cent*	*Cc.*	*Minutes*	*Grams per. cc.*	*p Pts. er lb. per ream*	*Grams per lb. per ream*	*Double folds*	*Lb. per sq. in.*	*Lb. per inch-width*		*Per cent*
1723	89.93	2.22	11.44	8.08	84.8	2	150	100	11.44	3.7	48.3	22.4									31.6	18.3
1712	89.93	2.22	17.16	12.0	83.93	2	150	97.6	11.71	4.8	54.7	1.9	860	0	0.41	0.54	3.64	.....	2,030	15.2	29.0	21.6
													570	20	.67	1.28	2.42	.....	6,040	27.6	.....	.....
													280	40	.65	1.30	1.61	.....	7,315	34.4	.....	.....
													200	60	.65	1.09	1.30	.....	8,260	38.7	.....	.....
													150	80	.70	1.34	1.56	.....	8,130	35.1	.....	.....
1713	89.3	2.24	22.85	16.0	83.93	2	150	87.6	14.02	6.0	51.6	.2	860	0	.47	.56	4.62	235	2,140	14.1	15.2	28.8
													815	5	.52	1.02	3.72	2,097	4,010	23.5	.....	.....
													760	10	.50	1.32	2.75	3,418	5,720	34.9	.....	.....
													700	15	.54	1.42	2.67	2,302	4,850	27.5	.....	.....
													615	20	.54	1.46	2.15	1,624	6,680	37.7	.....	.....
													520	25	.71	1.52	1.94	.....	7,190	30.7	.....	.....
													495	30	.64	1.52	1.63	1,345	7,860	37.2	.....	.....
1734	90.16	2.21	22.85	16.0	84.87	2	150	85.9	13.76	6.0	52.5	.2	412	35	.63	1.56	1.81	2,343	9,750	37.5	.....	.....
													850	0	.44	.61	5.24	867	2,850	19.6	14.5	29.4
													740	10	.57	1.31	3.07	2,639	6,300	33.6	.....	.....
													620	20	.61	1.54	2.58	1,970	7,350	36.7	.....	.....
													530	30	.60	1.28	2.34	1,814	7,790	39.7	.....	.....
													285	40	.67	1.30	2.27	1,660	8,320	37.9	.....	.....
													255	50	.69	1.30	1.88	1,797	9,140	40.3	.....	.....

													250	60	.74	1.46	1.90	1,838	10,040	41.5		
1724	89.2	2.22	28.59	20.2	83.93	2	150	73.4	14.83	6.8	49.3	.2	0								9.5	36.4
													770	10	.58	1.20	3.64	2,427	5,790	30.5		
													670	20	.58	1.42	2.85	2,143	7,410	39.9		
													600	30	.64	1.38	2.55	1,231	8,400	40.3		
													385	40	.64	1.25	2.12	2,176	8,370	39.8		
													300	50	.73	1.47	2.02	2,100	10,560	44.0		
1751	91.1	2.20	22.85	16.0	83.93	1	150	88.2	14.1	6.8	50.2	1.5	860	0	.44	.41	4.80		1,981	13.8	17.0	29.5
													760	10	.53	1.14	2.97		5,400	31.0		
													600	20	.61	1.23	2.38		6,800	34.1		
													440	30	.67	1.43	1.86		7,970	35.9		
													270	40	.63	1.34	1.93		8,260	39.6		
													230	50	.66	1.43	1.90		8,260	37.8		
													135	60	.71	1.41	1.71		8,320	35.8		
1752	91.1	2.20	22.85	16.0	83.93	3	150	95.3	15.2	5.3	50.3	.7	880	0	.50	.68	4.36		2,592	15.7		22.6
													820	10	.59	1.06	2.71		5,942	30.6		
													690	20	.61	1.29	2.10		7,580	37.8		
													600	30	.66	1.29	1.95		8,420	38.7		
													395	40	.69	1.34	1.69		7,560	32.8		
													320	50	.70	1.40	1.49		8,880	38.3		
													240	60	.73	1.37	1.51		9,320	38.6		
1735	90.16	2.21	22.85	16.0	83.93	2	160	91.2	14.6	6.0	49.0	.2	850	0	.45	.60	5.12		2,600	17.5	12.3	28.5
													755	10	.64	1.37	2.88		7,140	33.9		
													610	20	.58	1.28	2.22		6,760	35.2		
													455	30	.65	1.50	2.02		8,280	47.1		
													320	40	.66	1.42	1.85		8,610	39.0		
													255	50	.74	1.34	1.72		9,300	38.2		
													220	60	.70	1.57	1.64		7,740	33.5		
1733	88.4	2.25	22.85	16.0	84.37	2	140	88.6	14.19	6.0	50.4	2.4	850	0	.41	.57	4.88		2,060	15.3	19.2	
													755	10	.46	1.02	3.11		4,580	30.4		
													610	20	.56	1.12	1.91		6,640	34.6		
													470	30	.74	1.31	1.93		8,190	33.5		
													340	40	.65	1.34	1.78		6,840	32.4		
													255	50	.72	1.19	1.73		7,210	32.5		
													160	60	.76	1.32	1.60		8,380	33.6		
1753	90.15	2.22	22.85	16.0	83.93	3	140	94.8	15.2	5.8	50.8	1.5	860	0	.48	.48	4.67		2,310	14.6	15.5	28.3
													730	10	.57	1.18	2.88		6,020	32.2		
													550	20	.63	1.45	2.08		7,390	35.6		
													320	30	.66	1.45	1.93		8,580	39.5		
													230	40	.75	1.35	1.53		9,400	38.3		
													190	50	.74	1.36	1.53		8,590	35.4		
													165	60	.74	1.34	1.47		9,460	39.2		

[1] One hour was allowed for the temperature to rise to maximum.

The pulps from cooks 1712, 1713 and 1724 when processed in the test beater for 20 minutes developed a bursting strength of 1.28, 1.46 and 1.42 points per pound per ream, respectively, and a tensile strengths of 6040, 6680 and 7410 lbs. per square inch, respectively. A tear of 2.42 grams per pound per ream was attained for cook 1712, 2.15 grams per pound per ream was obtained from 1713, while 2.85 grams per pound per ream was reached in 1724. The small range of variations in the physical properties of the pulp due to a change in chemical ratio and concentration of the cooking liquor tends to show that pulping abaca waste could be satisfactorily accomplished under mild conditions provided the color of the pulp is not considered important. Pulp yields from mild cooking conditions are generally higher than those obtained from a more drastic type of digestion. Both high pulp yields and low chemical requirements, associated with mild cooking conditions, are advantageous from the point of view of conversion economy.

Maintaining other variables constant, a difference of from 1 to 2 hours in the cooking schedule had no distinct effect on the yield of screened pulp (cooks 1713, 1751 and 1752). With an increase of one hour in the time of digestion (cooks 1751 and 1713), however, a decrease of approximately 1.3 per cent in the screenings on the basis of the moisture-free weight of the material was noted. The total yields from cooks 1713 and 1751 were equal and differ from that of cook 1752 (51 per cent) by 0.8 per cent. The brightness of the pulp from the one hour digestion was slightly higher than the color of the pulps from cooks of longer duration. The pulp obtained from a two-hour digestion (cook 1713) developed, after 20 minute beating, a burst of 1.46 points, a tearing resistance of 2.15 grams per pound per ream and a tensile strength of 6680 pounds per square inch as compared to a burst of 1.23 points, a tearing resistance of 2.38 grams per pound per ream and a tensile strength of 6800 for a one-hour digestion (cook 1751). On the other hand, a three-hour cook (1752) gave a burst of 1.29 points, a tearing resistance of 2.10 grams per pound per ream and a tensile strength of 7580 pounds per square inch. From the standpoint of screened yield and physical properties of the pulps, the two-hour digestions at a maximum temperature of 150°C. with chemical ratios of 12 and 16 per cent on the moisture-free weight of the material were suitable for reducing abaca waste to pulp.

The significance of digestion temperature on pulp yields and on the physical properties of the pulp may be noted from the results obtained from cooks 1733, 1713, and 1735, which were digested at 140°C., 150°C. and 160°C., respectively. It was observed that there was a little difference in the yields of screened pulps when the temperature was increased from 140°C. to 160°C., although the screenings were reduced from 2.4 to 0.2 per cent. Cook 1713 which was digested at a maximum temperature of 150°C. gave the best yield of screended pulp and good physical properties which were practically indentical to those obtained from cook 1735 which was digested at a maximum temperature of 160°C. A pulp resulting from a low digestion temperature (cook 1733) seemed to exhibit low bursting strength compared to the strengths of pulps prepared at the higher temperatures.

TABLE 2.—*Physical properties of manila paper and hand sheet.*

Material	Bursting strength	Tearing resistance	Tensile strenght	Folding endurance
	Pts. per lb. per ream	*Grams per lb. per ream*	*Lb. per square inch*	*Double folds*
Experimental hand sheet (cook 1734)	1.54	2.58	7,350	1,970
Commercial manila paper [1]	1.40	----------	7,305	4,272

[1] Forest Products Laboratory Project 7253–J4.

The physical properties of one of the experimental pulps (cook 2734) beaten for 20 minutes are compared with those of a commercial manila paper in Table 2. In contrast to the identical tensile strengths of the two samples, the folding endurance of the experimental pulp, which could be considered satisfactory, is one half of that of the commercial manila paper. On the other hand, the bursting strength of the commercial sample is a little lower than that of experimental test sheet.

CONCLUSION

1. Abaca waste can be easily reduced to a suitable soda pulp under mild condition of digestion. The production of lighter colored pulps, however, requires slightly more drastic cooking conditions and employing higher temperatures and liquor concentrations.

2. Abaca can be satisfactorily reduced to pulp by cooking for two hours at a maximum temperature of 150°C. with from 12 to 16 per cent caustic soda (NaOH) based on the moisture-free weight of the material.

3. The rate of hydration on beating soda pulp from abaca waste is relatively fast. The pulp is sufficiently hydrated in 20 minutes to give a Schopper-Riegler freeness within the range of 550 to 700 c.c. and an average bursting strength of 1.33 points per pound per ream.

4. The lightest colored pulp had a brightness of 36.4 per cent. The color of most of the pulps was similar to that of kraft pulps made from wood.

LITERATURE CITED

1. CHIDESTER, G. H. The beating of Manila hemp rope stock in the Rod Mill.. Forest Products Laboratory Project 253–J4.
2. OSBORNE, F. H. Porous long fibered nonhydrated paper. Patent 2,045,096 (November 26, 1934).
3. RICHMOND, G. H. Philippine fibers and fibrous substances: their suitability for paper making Part III. Philip. Jour. Sci. 2 No. 2; (May, 81–107. 1907)
4. SALEEBY, M. M. The manufacture of paper from abaca. Philip. Agri. Rev. (1913), 23–27.
5. SHAW, M. G. AND G. W. BICKING. Manila rope waste for paper manufacture. Paper Trade Journal 84, No. 18; (May 5, 68–70 1927).

BOOKS

Books reviewed here were received from time to time by the Philippine Journal of Science and acknowledged in this section.

REVIEWS

Bergey's Manual of Determinative Bacteriology. By R. S. Breed, E. G. D. Murray and A. Parker Hitchens. Sixth edition. Baltimore, The Williams & Wilkins Company, 1948, 1529 pp. Price $15.00.

The sixth edition of Bergey's Manual of Determinative Bacteriology is to the present the most complete study of taxonomy and nomenclature of bacteria. The work is accomplished by the permanent nomenclature committee created by the International Society of Microbiologists.

The nomenclature used in the latest edition differs from that in the previous edition. In the present edition the nomenclature is based upon the similar antigenic structures which identify the serotypes rather than the species. The inclusion of the *Salmonella typhosa* in the *Genus Salmonella*, called formerly *Bacillus typhosus* and *Eberthela typhosa*, is an example.

Besides the committee, sixty contributors assisted in the preparation of this edition. Since this book is the product of extensive study of renowned bacteriologists and specialists it

is therefore highly recommended as a valuable reference material for all scientific institutions and researchers. The duplication of names of certain species of bacteria has been rather confusing to any one who is unaware of the existence of certain synonyms. The publication of this manual has solved that confusion. Furthermore, this book also gives the general rules of nomenclature and principles of taxonomy so that a student of bacteriology may readily recognize the terms used regularly in classification. Following the rules outlined in this book it is easy for the students to identify a certain microorganism which they may encounter in their research work.

The book is really an invaluable help. People interested in bacteriology should consider its acquisition as a real and permanent investment.—M. B.

Biochemical Preparations. By Advisory Board, W. Mansfield Clark and others; Editorial Board, Herbert E. Carter, Ed.-in-Chief. New York, John Wiley & Sons, Inc., ©1949. v.1. Price $2.50

This book is the first volume of what is to be hoped a rich and comprehensive contribution to detailed methods of the preparations of various substances of biochemical origin.

It follows the same trend as the series of Organic Synthesis and Inorganic Synthesis series—but as the title indicates the book gives detailed methods as to the separation and purification of certain biochemical products from natural sources, as well as synthesis of some from organic compounds.

Methods are claimed to be precise as they have been counterchecked.—F. M. Y.

Experimental Physics for Colleges. By Walter A. Schneider and Lloyd B. Ham. Revised edition. New York, The Macmillan company, 1949. 442 pp., illus. Price, $3.80.

The book is a revised edition of the text by the same authors on experimental physics for elementary students.

The new edition is, as the title indicates, intended for use in colleges . It is composed of 7 parts: Part 1, Units and Measurements; Part 2, Mechanics; Part 3, Sound; Part 4, Heat; Part 5, Electricity; Part 6, Light; Part 7, Notes and Tables. There are 34 chapters, 56 experiments and 12 standard tables. An index is included.

The authors succeeded in this new revised edition, in presenting the subject of experimental physics for colleges, in a clear and concise manner, particularly to those who want to pursue advanced studies in physics. The mathematical treatment is in

accord with those covered in the first year of college. Figures are included to help the reader in understanding the different principles involved in the experiments. Like any other book of this kind, numerous problems are given to increase its usefulness to both the instructors and students. The chapter on Notes and Useful Instruments and Procedures is a good addition to the book. As a whole, the book is recommendable as a reference or as a text to those interested in somewhat advanced treatment of experimental physics, especially those in colleges.—G. O. O.

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